Digital Economy and High-Quality Industrial Development

Qu Yongyi*
Institute of Industrial Economics (IIE), Chinese Academy of Social Sciences (CASS), Beijing, China

Abstract: *In the 14th Five-Year Plan period (2021-2025), China has vowed to pursue high-quality industrial development. The digital economy drives high-quality industrial development by creating means of production, reducing transaction costs, transforming industrial organization, and improving the efficiency of resource allocation. The digital factor has become a key factor of production for high-quality development. Digital and user-created innovations are the new normal for cross-sectoral integration and innovation. Great progress has been made in China's high-quality industrial development driven by the digital economy. The rapid development of digital industries and industrial digitalization have reshaped the industrial division of labor and helped the ascension of related industries towards the medium- and high-end links of the global value chains. However, China still faces numerous challenges in the development of its digital economy; it lacks indigenous industrial innovation, depends on foreign supply of core technologies, and is ill-prepared for industrial digitalization. Much work remains to be done to further coordinate the development of some industries and foster digital ecosystems for the symbiosis of industrial chains. In furthering the high-quality industrial development driven by the digital economy, China should stay at the forefront of digital innovation, promote digital governance, enhance data factor agglomeration, and foster digital talents.*

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1. Interaction between Digital Economy and High-Quality Industrial Development

The digital economy has received a great deal of academic attention while the traditional theories of economics cannot properly explain the phenomenon of the digital economy. Some academics, therefore, consider that internet technologies are transforming the basic nature of industry and posing a fundamental challenge to the traditional theories of economics. The digital economy has opened an important window of opportunities not just for economic growth in various countries, but for broadening economic theories. According to the rationale of economic theories, economic theory for the digital economy, referred to for short as "digital economics," should identify specific phenomena that traditional economics cannot properly explain. By broadening or revising existing economic theories, digital economics will provide logically more coherent and straightforward explanations of the digital economy and industrial development different from economic paradigms for traditional technologies.

* CONTACT: Qu Yongyi, email: quyy@cass.org.cn.
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1.1 Core Principles and Values of High-Quality Industrial Development

Recent years have seen rapid development in digital technologies led by big data, cloud computing, the internet, artificial intelligence, and blockchain. In this context, the digital economy has emerged as a vital force for reallocating global industrial resources and reshaping the competitive landscape. Countries have come to realize that the digital economy holds the key for them to take the lead in technological revolution and industrial change, propel industrial efficiency and growth to stay competitive, and foster new industrial growth drivers for high-quality industrial development.

In its current stage of economic development, China vows to pursue high-quality development as a dominant strategy, which implies a new mode, structure, and momentum of economic development to better satisfy people's growing needs. This means that the focus of economic development should shift from speed to quality under the new concepts of innovative, balanced, green, open, and shared development. On the supply side, efficiency should be balanced with quality for more efficient, equitable and sustainable development. China pursues innovation as the primary driving force of high-quality development, the key features of which include coordination and green; openness is a sure path towards high-quality development, and its fundamental goal is for the people to share the benefits of development.

In terms of resource allocation, high-quality development should increase the efficiency of resource allocation and address structural problems such as resource mismatch and misallocation, thereby making economic development more adequate, effective, balanced, innovative and sustainable. In terms of means of production, high-quality development entails transformations of economic quality, efficiency and dynamism driven by core factors of production, including innovation, technology, and data. Technological, product, process and managerial innovations will reshape the productivity of market entities, contributing to the creation and constant upgrades of an innovative economic system. At the industry level, high-quality industrial development encompasses the sophistication of industrial organization, sustainable industrial innovations, and improving industrial structure. It refers to an advanced state of the quality of industrial development accompanied by the upgrade of industrial structure and the emergence of new business modes.

From an industrial structure perspective, high-quality industrial development entails the upgrade and adjustment of industrial structure within and between the primary, secondary and tertiary industrial sectors. From the value and economy output perspective, the value of industrial development is not just about a systematic improvement in the productivity of various industrial organizations, but also about the symbiotic development between industry and the external society and environment. Industrial development should contribute to economic, social, and environmental performance, as well as the interaction between industry and society, and between industry and the environment.

Considering its core values, high-quality industrial development involves multiple dimensions such as industrial competitiveness, industrial ingenuity, sustainable industrial development, and industrial security. Industrial competitiveness includes international competitiveness and efficiency. Industrial ingenuity is the ability of an industry to innovate and derive value from innovation. It is measured by the intensity of R&D input, the number of patents, the share of indigenous inventions, the possession of critical technologies, and technology-related incomes.

Sustainable industrial development is measured by the economic, social, and environmental performance of industrial development. Industrial security refers to factor dependence and intra-industry coordination. While the former includes dependence on foreign technology, capital and equipment, the latter refers to the extent to which enterprises coordinate and share resources within an industrial chain, strengthening the resilience of industrial enterprises.

1.2 Rationale for High-Quality Industrial Development Driven by the Digital Economy

Under the digital economy, the implications of high-quality industrial development can be divided

into the following four levels:

(1) At the level of means of production, data has become a brand-new factor of production amid high-quality industrial development driven by the digital economy as opposed to labor, land, and capital in the traditional era of the industrial economy. Data factors may exist independently outside the production sector as a brand-new factor of production for industrial innovation and development. As a dominant industry in the traditional era of industrial economy, manufacturing underpins the real economy and relies on the traditional factors of production like labor, land, and capital. It takes human and intellectual capital to optimize and upgrade manufacturing, as well as financial capital to ease financial constraint that stands in the way of high-quality industrial development.

However, in the digital economy, data has become a core driving force of productivity embedded in every process of industrial development from R&D to industrial design, manufacturing, and sales. Resource allocation efficiency has been enhanced thanks to data-driven open innovation networks, smart manufacturing, and customized user services. Not only does data effectively link various processes of the industrial chain, but it also enables data transmission, big data analysis, and artificial intelligence, among other digital technologies that synergize various links of an industrial chain. Once combined with other factors of production such as labor and capital, data will derive more value from traditional factors of production in various links of the industrial chain.

(2) From the traditional industries standpoint, cooperation and innovation usually take place between upstream and downstream enterprises, as well as among enterprises, universities, and research institutions. Given the exclusivity of knowledge and the technological monopoly of leading enterprises with each industry, it is costly for various innovation entities within each industry to collaborate and share knowledge, which has inhibited industrial innovation to some extent. With their heft and resourcefulness, established large enterprises have crowded out small and medium-sized enterprises (SMEs) from innovation, thus inhibiting their development.

The digital economy is poised to upend industrial innovation networks and boundaries in several ways. Because of the innovation and inclusiveness of digital technologies, the digital economy has reshaped the industrial open innovation network, allowing various innovation entities within each industry to interact with each other instantaneously. This redefines cooperation between upstream and downstream enterprises of each industrial chain, transforming sporadic cooperation for innovation into systematic innovation driven by digital technologies, which allows innovative entities to concentrate virtually and engage in online and offline coordination. In such an industrial digital innovation ecosystem, it is cheaper for innovation and knowledge entities to cooperate for innovation and absorb, capture, share and integrate knowledge. Within each industry, innovation entities of all types may accumulate innovation resources to the greatest extent for value co-creation.

The digital economy is expediting inter-sectoral integration at an unprecedented speed, blurring the traditional boundary between the primary, secondary and tertiary industrial sectors. In a digital economy environment, the trend towards service-based manufacturing in the secondary sector industry becomes increasingly evident. From mass production lines and small-scale customization, manufacturing is shifting towards service-based customization on a mass scale. In other words, industrial innovation in the digital economy is becoming less product-centric and more service-centric. Accordingly, inter-sectoral integration has also derived a constellation of digital services and product innovations.

Under the digital economy, user-driven industrial innovation has become the new normal. The traditional theory of user innovation puts a greater premium on the forces of leading users, who play a key role in product design and standardization and lead the iteration of product and service standards amid industrial innovation. Under the digital economy, all users, both leading and non-leading, may participate in every link of industrial innovation from R&D to manufacturing, service, and sales, thus playing a more active role in industrial innovation.

(3) Traditionally, leading enterprises become more efficient under the effects of economies of scale and economies of scope. Competition between industrial entities is subject to high barriers, i.e. intra-industry competition often takes place with leading enterprises increasing their market concentration to reap more profits. One leading technology takes hold in the industry, and established large enterprises squeeze profit margins by means of technology monopoly or standards, inhibiting the diversification of intra-industry innovation. Under the digital economy, platform enterprises have replaced traditional enterprises as the dominant form of industrial organization, and the market scope linked by digital platform enterprises has also extended from traditional one-sided markets to two-sided markets.

By creating interactive platforms for transaction and innovation, platform enterprises bring together two-sided users and complementary actors for value co-creation and shared value addition. They participate in the market competition under the same-side network effect and the cross-side network effect unique to two-sided markets. Accordingly, the roles of traditional producers, consumers and other industrial entities become redefined under the paradigm of industrial organization where platforms hold sway, blurring the boundary between upstream and downstream enterprises. This will give rise to the integration of industrial chains and ecosystems. Within various industrial chain clusters, dominant enterprises will drive cross-ecosystem value co-creation, engender innovative technologies, business modes and paradigms, and reshape industry-wide ingenuity and coordination.

(4) High-quality industrial development hinges upon the security of industrial chains, which refers to the resilience of firms in an industrial chain against major external shocks or uncertainties. In traditional industrial chains, various innovation entities share little information. Even if a few enterprises share information for innovation, such exclusive cooperation may not induce collective action to strengthen the security of the entire industrial chain.

However, under the traditional economy, coordination between industrial chains is costly, and the relocation of industrial chains is even more so. Uncertainties or non-economic repercussions experienced by a core enterprise will lead to chain reactions across the industrial chain. During the COVID-19 pandemic, for instance, the interruptions of a key enterprise could disrupt or even dislocate the entire supply chain. In the digital economy, however, enterprises contribute to the digitalization of the entire industrial chain and work together to innovate in both online and offline forms. With the help of digital technologies, core industrial chain enterprises can stay informed about upstream and downstream risks. Therefore, from the perspective of the flexibility and resilience of the industrial chain supply chain, digital interconnection among enterprises will greatly enhance industrial chain flexibility. When struck by external uncertainties, core industrial chain enterprises should be able to re-establish and reorganize the industrial chain based on digital technologies. They should be able to carry out cross-sectoral reorganization and resource reallocation and overcome the effects of isolation.

2. High-Quality Industrial Development Driven by the Digital Economy: Current Status and Key Problems

Since the 18th CPC National Congress, the Chinese leadership, with General Secretary Xi Jinping at its core, has elevated the development of the digital economy into a national strategy as part of the great rejuvenation of the Chinese nation in response to the great changes taking place in the world. Continuous efforts have been made to improve digital infrastructures, foster new business modes, develop digital industries, and steadily advance industrial digitalization. This has laid a solid foundation for China to realize its global technological revolution and industrial transformation. In the new round of international industrial competition, China is ready to play a leading role in future-oriented industries, mainly by strengthening future technology prediction and R&D to promote the emergence of future industries.

Yet challenges ahead are sobering: China's digital economy development remains unbalanced and inadequate. The potential of digital economy to boost industrial development has yet to be fully unleashed and the digital industry's governance still needs further improvement. China's economy must deal simultaneously with slower economic growth, difficult structural adjustments, and the impacts of previous economic stimulus measures. Given the changing global geopolitical situation and the COVID-19 pandemic, China's external development environment has changed in significant ways. Numerous difficulties lie ahead in promoting high-quality industrial development driven by the digital economy. China's industrial system modernization still has a long way to go.

2.1 Great Achievements in Promoting High-Quality Industrial Development Driven by the Digital Economy

The Chinese government has enacted policy and normative documents on the digital economy, which include the *Outline for Implementing the National Cyber Development Strategy*, the *Plan for the Development of the Digital Economy in the 14th Five-Year Plan Period*, *Opinion on Creating Fundamental Data Systems to Better Leverage Data As a Factor of Production*, and the *Work Scheme for Enhancing Supervision over Large Payment Platform Enterprises and Promoting Standard and Healthy Development of Payment and Financial Technologies*. The importance of developing the digital economy is well-appreciated among the public. The digital economy provides a powerful impetus for sound industrial and economic development.

China leads the world in terms of digital infrastructure. It has built the world's largest optical fiber and fourth-generation (4G) mobile communication networks and ranks first in the world in terms of the number of subscribers to mobile gigabit (5G) and fixed-line gigabit (optical fiber) internet. Innovation has proliferated thanks to digital technology applications. China has filed over 30,000 patent applications under the Patent Cooperation Treaty (PCT) (up 60% from 2017) which represents 37.8% of the world total with an annual average composite growth rate of 13.6%. China has made steady progress in industrial digitalization, substantially increased service digitalization, expedited industrial digitalization, and increased the digitalization of industrial enterprises.

With more enterprises connected to the cloud, the big data industry has seen a rapid increase in its gross output from 470 billion yuan in 2017 to 1.3 trillion yuan in 2021. Digital applications in various industries have allowed e-commerce to thrive, and have popularized mobile payment and several other new ways of life and work such as online learning, teleconferencing, online shopping, and video streaming. Internet platforms have gained influence; digital industries, such as artificial intelligence, big data, blockchain and cloud computing have made great headway, as reflected in new business modes such as mobile payment, video streaming, teleconferencing and smart logistics. China's digital economy has grown from 22.6 trillion yuan in 2016 to 45.5 trillion yuan in 2021 with its share of GDP up from 32.9% to 39.8%, ranking second in the world in terms of aggregate value.[1]

China has continuously deepened international cooperation in the digital economy. With their growing influence and competitiveness, Chinese digital platform enterprises have rushed to go global. Great progress has also been made in e-government, digital social services, and digital governance. This has led to more integrated and effective government services and regulatory functions. As a result, citizens may complete administrative applications at a single government website or visit a government office online for various purposes. Thanks to an improving digital business environment, China leads the world in terms of online government services with remarkable achievements in the development of e-government.

[1] Data are from *Report on Digital China Development (2021)*, see Zhang Shiyao's "Data shapes the new landscape and leads the future," *Guangming Daily*, July 24, 2022.

2.2 Rapid Development of Digital Industries and Industrial Digitalization

Digital industries and industrial digitalization are the main forms of the digital economy that drive high-quality industrial development. While the former refers to new industries driven by digital technologies such as software, telecom, IT manufacturing and internet, the latter relates to digital applications in traditional industries to increase productivity and efficiency. The academia has yet to agree on the definition and measurement of digital industries and industrial digitalization, but suggestions from the China Academy of Information and Communications Technology (CAICT) have started to gain recognition.

As the digital economy grows and makes up a rising share of GDP, China's digital industries and industrial digitalization is advancing briskly. Moreover, digital industries are experiencing a shift from quantitative expansion to qualitative improvement. According to the *White Paper on China's Digital Economy Development* released by the CAICT, China's digital industries have steadily increased in value over recent years, reaching 8.35 trillion yuan in 2021, up 11.9% in nominal terms from the previous year. They represent 18.3% of China's digital economy and 7.3% of China's GDP. On the other hand, the value of industrial digitalization reached 37.18 trillion yuan in 2021, up 17.2% in nominal terms from the previous year, making up 81.7% of China's digital economy and 32.5% of China's GDP.[2]

Alongside the thriving digital economy, the digitalization of traditional industries has been picking up speed. The digital economy has unlocked great potential for digital innovations to empower traditional industries. The most significant among them is the manufacturing industry, where the trend toward digitalization is particularly evident. According to a survey on the digital transition of China's key sectors conducted by CCW Research - a leading Chinese IT market research and consulting firm, the market size for China's manufacturing digitalization expanded from 200 billion yuan in 2018 to 250 billion yuan in 2020.[3]

The industrial internet is a poster child of how digital transition may transform the traditional manufacturing industry. In 2019, China's industrial internet economy generated 2.13 trillion yuan in value-added, up 47.3% from the previous year. In 2020, this number jumped over tenfold, to 26.59 trillion yuan. In the same year, 365 million Chinese households were connected to 5G terminals, and China owned over 38% of 5G standard essential patents (SEPs) declared worldwide. [4]Industrial internet platforms are becoming pivotal for the digital transition of China's manufacturing industry and the upgrade and transition of traditional industries under the digital economy.

2.3 Critical Technologies Remain Key to China's Digital Economy and High-Quality Industrial Development

Since 1978 China has emerged as the world's factory floor thanks to its large domestic market, inexpensive labor, and pro-export environment. Due to changing domestic and international situations and rising costs of labor, land and other means of production, China's traditional comparative strengths have waned. While some industries have thrived on processing trade in the earlier stage, there is still room for improving the quality, reliability, durability, and consistency of finished products. They remain highly dependent on foreign supplies of essential parts and components, key materials and technologies. Some industries are subject to foreign technology barriers, monopolies, and embargoes. Those restrictions are challenging China's digital economy and industrial competitiveness.

Recent years have seen turbulent changes unprecedented in a century. Amid a backlash against

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[2] *Report on Digital China Development (2021)*.

[3] CCW Research. *Report on Market Situation and Development Trend of the Digital Transformation of China's Key Industries*, 2019-2020, April 1st, 2020.

[4] The China Academy of Information and Communications Technology (CAICT). *Report on the Development of China's Industrial Internet*, November 21, 2021.

economic globalization, countries have become increasingly divergent. Global industrial and supply chains tend to center around certain trade blocs, localities, and regions. The rise of some developing countries has structurally transformed the global economy. Meanwhile, the great-power contest between China and the US has escalated. Some Western countries led by the US have barred China from accessing advanced and emerging technologies of vital military importance and imposed multilateral export controls against China. Not only is China restricted from investing in US technology, but anyone from China is barred from accessing sensitive laboratories in the US. In addition to putting up barriers, the US has also launched indiscriminate attacks against China's high-tech sectors and advanced manufacturing – not least digital communication, industrial machine tools, high-end chips, quantum computing, artificial intelligence (AI), data analysis and storage, development platforms, basic algorithms, software, components, and materials, as well as sophisticated equipment. These restrictive measures, aimed at locking up Chinese industries at the medium- and low-end links of industrial and value chains, have put excessive pressure on China's digital economy and high-quality industrial development.

2.4 Weaknesses of China's High-Quality Industrial Development

One weakness facing China's industrial development is the lack of cooperation. Within individual industrial chains, companies with upstream and downstream links have yet to share and complement resources with each other. Effective mechanisms have yet to take hold to promote common development and share interests between neighboring regions. Take the integrated circuit (IC) industry for instance: The stampede of local governments for IC projects has led to repetitive and inefficient investments. Instead, there should be more coordination for advanced chip manufacturing, equipment, materials, and EDA software. Similarly, it takes complete and sophisticated industrial chains and supporting systems to develop advanced equipment manufacturing. Yet digital professionals are in short supply and new material R&D input is far from sufficient. In the early reform era, China's state-owned research institutions suffered from a severe brain drain after the corporatization reform, which led to a lack of innovation and undersupply of generic technologies. The long profit cycle of R&D investment has also deterred companies from developing generic technologies, the lack of which has stymied firm innovation and industrial chain modernization. As a result of underfunding of forward-looking research on critical generic technologies, China still relies on imported high-end CNC machine tools and industrial software. In the seed industry, the lack of original innovation of critical biotechnologies undermines China's agricultural security.

3. Policy Recommendations for Deepening High-Quality Industrial Development Driven by the Digital Economy

3.1 Creating a New Industrial Foundation according to the Trends of Digital Economy Development

As can be seen from the history of world economic development, technological and industrial revolutions in various countries have different manifestations depending on their cultures, institutional systems and technological innovations. The premise for technological and industrial revolutions to take place in a country or region is the dissemination of new ideas, the accumulation of domestic knowledge, and extensive applications of new inventions and technologies. In catching up with advanced industrial economies, a country must enact a string of institutional and policy changes to implement the adoption of new technologies. We should seize the opportunities to improve the dynamism, efficiency, and quality of our country's technological and economic systems. This requires us to address various institutional contradictions and challenges arising from changes in productivity and relations of production caused by the development of digital technologies and the digital economy.

In promoting high-quality industrial development driven by the digital economy, we should fully leverage our country's strengths of market heft, large data volumes and extensive use cases, and wean from dependence on foreign supply of certain essential products and technologies by developing critical generic technologies. Priority should be given to developing key digital technologies, the possession of which will contribute to the digital economy's development and national economic security. We propose the following actions:

First, we should expedite industrial internet innovation and development. Under the strategy of industrial internet innovation and development, industrial enterprises should be encouraged to upgrade their intranet and internet capabilities with 5G, time-sensitive networking (TSN) and other technologies, and promote the interconnection of enterprise office, production management, monitoring and early warning, industrial control, Internet of Things and other networks under the premise of safety and reliability, so as to accelerate the IT OT network integration. A few internationally competitive industrial internet platforms should be created with enhanced security assurance. The digital transition should be accelerated for all sectors.

Second, we should raise the level of digitalization in the business sector and create a smart supply chain system underpinned by big data, shared networks, and intelligent cooperation. The public service system for e-commerce should be improved to promote and support the digital transition of small and medium-sized businesses. Concerning trade digitalization, traditional businesses in retail, wholesale, hospitality, catering, leasing, and commercial service sectors should be guided to embrace both online and offline, customized, and targeted marketing innovations throughout their sales channels.

Third, we should conduct demonstration programs for industrial digital transition, including pilot actions for smart manufacturing. Digital transition roadmaps should be drafted to address the challenges facing individual industries. Key sectors such as raw materials, consumer goods, equipment manufacturing and IT should demonstrate and evaluate digital applications and promote flagship ones.

3.2 Implementing the New Development Concepts and Identifying the Trends and Priorities of Digital Economy Development

Development concepts provide scientific guidance for overall development and lead development initiatives. Recognizing the problems of economic efficiency and structure, the 13th CPC National Congress called for transitioning from a crude pattern to an intensive model of economic operation. The 15th CPC National Congress adopted the strategy of sustainable development. The 17th CPC National Congress further identified the strategic priorities to shift the way of economic development. The 19th CPC National Congress assessed China's economic transition towards high-quality development under the new concept of innovative, balanced, green, open, and shared development. These interlinked concepts represent the direction and priorities of development.

In promoting high-quality industrial development driven by the digital economy, we must implement new development concepts in all areas and follow the trends of digitalization, giving priority to technological and institutional innovations. In analyzing and addressing problems, we should take the initiative to abstract and decompose problems, and create problem-solving models, algorithms and paradigms through iteration and optimization.

The new digital economy should promote extensive cooperation between various economic and social entities, promote the overall development of human society, and solve the digital divide and the series of inequalities and wealth distribution imbalances caused by digital capital.The digital economy should be green and contribute digital resources, tools, and platforms to green development for man and nature to live in harmony. Openness is a sure way for the digital economy to promote high-quality industrial development. In this respect, China should integrate itself into the global digital economy, take an active part in global digital governance, and promote domestic and international interactions for high-quality industrial development driven by the digital economy. The goal is to share the benefits of

development and improve people's welfare. In accordance with digital ethics, we should safeguard the healthy order and ecosystem of the digital economy.

3.3 Beefing Up Industrial Innovations to Acquire Choke-Point Technologies

After decades of development, China has shifted from integrated innovation, assimilation, and re-innovation in the catch-up stage to original innovation of frontier technologies. In some digital technology sectors, China has transformed from a follow-up to a leader. However, China's industrial R&D gaps are quite significant, as reflected in the lack of fundamental scientific research, underlying basic technologies and process capabilities, as well as bottlenecks Concerning high-end chips, basic software and hardware, development platforms, algorithms, and critical components. There is not enough interplay between human resources, equipment, software, digital infrastructure, and digital use cases. Choke-point technologies for some strategic industries are still subject to foreign monopolies or embargoes. Therefore, from the perspective of the breakthrough mechanism of obtaining key and core technology, China should increase the R&D investment in indigenous innovation to obtain the autonomy of key digital technologies supporting the digital economy and improve the controllability of key and core technologies.

Under the analytical framework of market demand, industrial goals, technology barriers and R&D priorities, we should identify digital technology trends and critical technologies for China's industrial development, as well as their timelines and pathways of realization, market prospects, and problems to be addressed. Research should be conducted for critical digital technologies with broad applications. Following the laws of industrial and digital economy development, innovation entities should cooperate, identify technical solutions to meet market needs, and promote technological, product, and organizational innovations that would bolster China's industrial competitiveness.

First, we should identify the current status of China's digital technology development and gaps with developed countries, identify critical technologies of priority development, and focus on frontier technologies of strategic importance such as sensors, quantum information, network communication, integrated circuits, key software, big data, artificial intelligence, blockchain, and novel materials. We should enhance R&D for digital technologies based on the strengths of our socialist system and market heft.

Second, we should forecast the trends of technology development leading to our goal of high-quality industrial development. Technology selection and planning should be conducted before taking important decisions on technology development and commercialization. Following this approach, we should focus on the development of key technologies for high-end chips, processing systems, industrial software, and core algorithms and frameworks producing trump-card general-purpose processors, cloud computing systems and leading-edge software technologies.

Third, we should strengthen industrial chains and promote technology integration and product innovation for widespread use. Priority should be given to the domestic supply of basic software and hardware, critical electronic components, basic materials, and manufacturing equipment. Important supply chains should be improved for 5G, integrated circuits, new energy vehicles, artificial intelligence (AI), and industrial internet for the key links of industrial chains to become more competitive.

3.4 Multiplier Effect of Data in Enhancing Industrial Efficiency and Momentum

In the era of the digital economy, data as a critical factor of production is the foundation for supporting digital, network-based, and smart industrial systems. It is also pivotal to transforming the mode of production, lifestyles, and social governance. At the legislative level, China has yet to clearly define the rights to own, collect, use, and share data. Work remains to be done to establish a sound data security governance mechanism, regulate the data market, and define the roles of algorithms and computing in the digital economy. In promoting high-quality industrial development, we should

attach significant importance to understanding, displaying, analyzing, and developing data and digital technology tools. In the digital economy, data is conducive to innovation and permeable in a broad range of sectors. The following insights should be extracted to improve the quality and efficiency of traditional means of production such as labor, capital, technology, and management to enhance industrial efficiency and development.

First, we should give full play to the multiplier effect of data by improving data supply and quality. Exponential growth of big data and the digital economy provide opportunities to speed up the adoption of emerging information technologies such as 5G, artificial intelligence, the internet of things (IoT), cloud computing, big data, virtual reality and edge computing. Work must be done to enhance data collection, storage and analysis and develop data applications for manufacturing, distribution, consumption, and social services. Priority should be given to data labeling, cleansing, desensitization, decryption, synthesis, and analysis to step up data processing capabilities. Barriers to technologies and protocols should be overcome by increasing data sharing, exchange, coordination, and openness. We should strive to improve data management through data classification and standardization, apply big data for R&D, manufacturing, logistics, services, and other key links of industrial chains.

Second, China should fully tap the potential value of its abundant data resources and expedite the market-based circulation of data. As a means of production, data should transform the modes of production and management for traditional industries and contribute to China's economic momentum, total factor productivity (TFP) improvement, technology progress, and industrial upgrade. Market circulation of data should be encouraged by creating data market rules and fostering market entities. Market entities should catalog data assets and explore their pricing mechanisms. The government should regulate data transaction platforms and market entities. It should create market systems for data asset evaluation, registration and settlement, transaction matchmaking, and dispute arbitration. Efforts must be made to create a secure and orderly market environment and increase data transaction efficiency by establishing data rights and regulatory rules for data transactions and circulation, conducting security management and process supervision and cracking down upon the data black market.

Third, we should innovate the mechanisms of data development and utilization. According to the characteristics of several types of data, we should create diverse mechanisms for data development and utilization to meet data needs in various areas. Market forces should be encouraged to explore the value of commercial data, offer professional and individualized data products and services, and integrate data with technologies and use cases. Key sectors should be encouraged to adopt innovative modes of data development and utilization, and under the premise of data security and privacy protection, involve industry associations, institutions of scientific research and enterprises for data development. Private actors should be incentivized to make use of available government and public data of economic and social importance by means of data openness, licensed development, and authorized use. In developing smart cities, we should integrate urban data, foster industrial ecosystems, and promote efficient and fair distribution of profits from data in China's digital economy to develop along the correct path.

5. Fostering Digital Professionals for High-Quality Industrial Development under the Digital Economy

In the words of General Secretary Xi Jinping, "In all things in this world, people are the most precious; and all innovative achievements are produced by people. Hard power or soft power, when it comes down to it, it all depends on the power of talent."[5] While China continues to explore institutional systems for attracting global innovation talents, it is faced with a shortage of highly qualified talents,

[5] Xi Jinping. A speech at the joint session of the 19th Meeting of the Members of the Chinese Academy of Sciences and the 14th Meeting of the Members of the Chinese Academy of Engineering, May 28, 2018.

especially digital and cross-disciplinary professionals. China's talent evaluation system is unreasonable and the personnel management system is incompatible with the needs of technology innovation. Incentives for innovation and creativity are inadequate. Great endeavors cannot be achieved without talents. We should remove all ideological and institutional barriers to the attraction and growth of talents to attract top-notch innovators. Only when the whole people develop digital competencies and skills will it be possible to foster professionals for the digital economy and high-quality industrial development. In this regard, our priorities are threefold:

First, we should establish mechanisms for talent recruiting and development and create a policy environment conducive to innovation and entrepreneurship. The key to acquiring talent is to broaden the channels of talent identification. The government should enact policies to attract highly qualified digital professionals to China for innovation and entrepreneurship. Mechanisms should be created to identify, train, and make the most of human talent. According to the norms of talent development, we should address the structural contradictions of human resources, create a complete talent echelon, and foster a crowd of researchers and innovators.

Second, we should enhance the digital literacy and skills of the public and promote "digital champions" in various disciplines and sectors. Specifically, it is important to increase digital resources and open them more broadly to the public to foster digital awareness, computational thinking, digital learning and innovation, digital security and sensitivity, and digital social responsibilities. In this manner, the public should be able to identify price discrimination enabled by big data and algorithms. Special attention should be given to professionals with an in-depth understanding and extensive experience about the digital economy and high-quality industrial development referred to as "digital champions." Their cross-disciplinary knowledge and expertise will help industrial enterprises communicate with the external environment and between their internal functional segments. In this manner, digital knowledge and high-quality industrial development can be communicated to other industrial enterprises or their internal members. This will create conditions for them to appreciate how data are collected and shared and how algorithms are adopted and for what purpose.

Third, we should improve talent evaluation and incentives and establish an intellectual cost compensation system for innovators. Talent evaluation should focus on the extent to which technology talents contribute to innovation and encourage them to conduct research and innovation. Importance should be given to both personal and team evaluation to respect and recognize the contributions of all team members. Technology incentives should be improved to ensure reasonable reward to innovators. We should put people first and give greater autonomy to innovators to incentivize their enthusiasm and creativity. Intellectual cost compensation should consider the scientific, economic, and social values of innovation.

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