

# **China's Digital Transformation and Its Implication for the Asia-Pacific**

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## China's Digital Transformation and Its Implication for the Asia-Pacific

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### Introduction

At present, digital transformation centered on the use of smart information technology to change the economic and social activities is expected to generate substantial digital economy and digital dividend. As a general purpose of technology, smart digital technology has strong properties of platforms, openness, integration, and ecosystem, which will impose broad impacts on the innovation, entrepreneurial activities, investment, trade, and industrial development. Currently, the Asia-Pacific region arrives at a critical point to overcome the structural problems, shape the economic momentum and pursue the quality oriented economic growth. Therefore, all the Asia-Pacific economies have reached a broad consensus in the exploitation of the digital economy and dividend. They seek to give full play to a leading role of digital transformation in improving labor productivity, creating business opportunities and promoting free trade in order to better achieve sustainable development and inclusive and secure growth in the Asia-Pacific. China, one of the most important economies in the Asia-Pacific, is also undergoing an unprecedented digital transformation. Due to the scale and systematic integration effects of digitalization, it can be expected that China's huge market potential, rich application scenarios, and urgent upgrading needs may bring not only historical opportunities for digital economic cooperation in the Asia-Pacific region but also essential incentives for this region to form a more intimate innovation community.

This paper consists of three parts. The first section attempts to summarize the characteristics of the new round of digitalization induced by smart digital technologies. Moreover, it further develops a digitalization matrix as a framework to capture the feature of digital transformation. In the second section, the paper moves towards the analysis of status-quo and trends of China's digitalization by using the digitalization matrix. Finally, it identifies possible opportunities for boosting the digital economy to pursue quality-oriented economic growth and regional integration in the Asia-Pacific region by China's digitalization.

### A New Round of Digitalization: Characteristics and Elements

#### The Characteristics of the New Round of Digitalization

Information and Communication Technology (ICT) plays a crucial role in digitalization as the ICT is often used

and developed as a part of the process of ongoing adoption of digital technologies to change the economy and society.<sup>1</sup> Since the 1950s, four generations of computers have evolved. Each generation reflected hardware changes in size and capability enhancements in computer operating systems. Primarily due to the dramatic improvements in computer components and manufacturing, computers today can do more than the largest computers of the mid-1960s at about a thousandth of the cost. Furthermore, the technological progress of ICT in the last several decades is much faster than we expected. The breakthrough in the ICT in the last decade results in the emergence of smart digital technologies such as Artificial Intelligence, the Internet of Things (IoT), Cloud Computing, Cyber-Physical Systems and Big Data, which has launched a new round of digitalization. For example, computer scientists began tinkering with AI in the 1950s, but it is only in the last decade that AI has been realized when new applications were able to be unlocked thanks to hardware developments, including faster processors and more abundant storage, larger data sets, and more capable algorithms.<sup>2</sup> The smarter digital technology blurs the boundary among the physical, digital and biological world, which is one of the most prominent features in the current digitalization as Schwab (2017) called it as the Fourth Industrial Revolution. In this way, digital technology diffuses into every corner of our social and economic life, enhancing the potential of individuals, enterprises, industries, and government within the whole economy.

Although the smarter digital technologies, a part of ICT, have stronger properties of the ecosystem. Its broad application emphasizes the growing significance of the role of digital resources and platforms, the potential of smart manufacturing, and the necessity to improve digital governance. These features bring about substantial changes to the social and economic activities in the new round of digitalization. The first significant change is that the role of data and platform in business and social governance has become more significant than the past. The data and platforms can seldom be regarded as an invaluable resource or a driving force of business and innovation in the early stage. However, the volume of data has surged in recent decades due to the progress in digitization. A rapid rise in smartphone ownership has also provided consumers greater access to platforms. Especially when clouding computing, network and Internet access have become the critical digital infrastructure, a larger volume of data can be collected, stored and analyzed more smartly. With the broad application of smart digital technologies, data and platforms are crucial to business in many cases and become a new and essential factor in production. More private companies have been attracted to the investment on the digital infrastructure and platforms as their main profit sources.

The smart digital technologies such as IoT and machine learning also enable the improvement of efficiency and cost of manufacturing. For quite a long time, digital technology was always applied to social interaction. The progress of the production automation via digitalization was limited due to the high cost and technological immaturity. Therefore, the digitalization imposed little impacts on the enhancement of output and efficiency as described in Solow Paradox. Thanks to better and cheaper sensors that can record everything from temperature and light to sound, humidity, chemical composition, pressure, and other factors, IoT has a wide variety of potential applications, ranging from tackling macro-level challenges like traffic congestion and pollution to monitoring micro-level operations like quality control and improvement in a factory. Consequently, we witness not only automation upgrades in production but also the increasing level of connectedness and self-adaptation in

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<sup>1</sup> Although some minor and ignorable differences may exist, digitalization, digital transformation, and digital economy are interchangeable in many cases. In addition, digitization refers to the process of encoding analog information into zeros and ones so that the information can be stored, read, processed, and transmitted by computers. Therefore, we use the term digitization at a more micro-level but digitalization at a more macro-level.

<sup>2</sup> <https://itif.org/publications/2018/09/04/itif-technology-explainer-what-artificial-intelligence>.

manufacturing, resulting in large-scale positive effects regarding productivity enhancement. That is why almost all the countries regard the Industrial Internet as one of the top priorities in their strategies of the digital economy.

Also, smart digital technology highlights the significance of the digital ecosystem and digital governance. For example, using digital ledgers that record distributed information among computers, blockchains creates a decentralized ecosystem which can be applied to various scenarios. In order to ensure the sustainability and security of the ecosystem, we should design relevant risk control mechanisms and standards to create a favorable regulatory environment. As the role of platform is pronounced in the smarter digital world, many digital giants like Google, Facebook, and Tencent prefer to enhance their core competitiveness by establishing the platforms, which enables the numerous entrepreneurial SMEs to have access to more resources online. A highly complex and connected digital environment also brings many challenges in terms of governance. In the era of the digital economy, anyone who wants to tap into the advantages from digitalization must embrace the digital transformation by providing personal information like habits and preferences. Because smart digital technology has stronger capacities to integrate the relevant information, the urgency of protecting privacy and enhancing data flow is growing dramatically. That is why the EU passed the General Data Protection Regulation on the one hand, and formulated the policies to promote the free flow of non-personal data on the other hand. The latter is considered as the critical building block of the Digital Single Market and expected to unleash the full potential of data economy and to double its value to 4% of GDP in 2020.

### **The Digitalization Matrix: A Framework to Capture the Elements and Progress<sup>3</sup>**

Essentially, the digital economy is the outcome of digital transformation driven by smart digital technology. On the one hand, smart digital technology not only allows technology to expand human strength and human intelligence but also diffuse into every corner of all economic and social activities, which makes digital transformation widely happen in factors, industries, and governance. On the other hand, even in the same area, the link smart digital technology acts on has a significant impact on the transformation itself. For example, the currently hottest artificial intelligence technology seems to encounter a modern version of productivity paradox, and the lag in technological deployment and industrial restructuring is most likely its cause (Brynjolfsson et al. 2017). Therefore, based on the characteristic of the new round of digitalization involved with smart digital technologies, Zhang (2018) developed a 2×3 matrix as a framework to capture the elements and progress of digitalization (Table 1). It has three columns which correspond to the three features in the new round of digitalization, namely factor, industry, and governance. The matrix also has two rows which categorize elements into the production/physical or the consumption/application sides according to their distances to the customer. The matrix allows us to go beyond the firm-level analysis and traditional industry classification to capture this new round of digitalization comprehensively. More importantly, this departure also enables us to exhibit the strength and weakness of China's digitalization.

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<sup>3</sup> More details about the definition and measurement of digitalization matrix can be referred to Zhang (2018).

**Table 1 Digitalization Matrix**

<b>Consumption/ Application side</b>	Data collection and application	Digitalization of consumption and trade	E-regulation
<b>Production/ Physical side</b>	Digital talents education and digital infrastructure	Digitalization of production process	Data security and transaction rules
	<b>Factor</b>	<b>Industry</b>	<b>Governance</b>

Source: Zhang (2018).

Factor digitalization mainly refers to changes in the types, forms, and connotations of factors and their broad application with the backdrop of the digital economy. Its production/physical side includes factors like digital skills and digital infrastructure, both of which are critical input factors in the digital economy. For example, digital literacy is regarded as an increasingly important part of human capital in the view of UN. Abiad et al. (2018) find that better-performing middle-income countries (MICs) tend to invest more in the ICT infrastructure which produces more significant and sustained impacts on output in MICs than in low-income countries. The consumption/application side includes the factors related to ICT usage which reflects the extent the data are collected and utilized by the public.

Industrial digitalization mainly refers to the adoption of digital technology to strengthen the business in aspects of efficiency and profit. The production/physical side consists of the elements such as digitization of production process, digital transformation in the supply chain, and so on. For example, the IoT enables a real-time flow of information about the operational status and condition of equipment with a large amount of value created. The application of IoT is projected to generate 1.2 to 3.7 trillion US dollars of value globally by 2025 (Manyika et al. 2015). The consumption/application side contains not only the consumption and trade of digital products and services but also the broad utilization of e-commerce. In 2017, e-retail sales accounted for 10.2 percent of all retail sales worldwide, which is expected to reach 17.5 percent in 2021 according to the Statista's analysis.

Digital transformation in governance mainly refers to improving regulation with digital technology and dealing with the new regulatory challenges incurred by the digitalization. Its production/physical side includes the data security, transaction rules, and standards. They are more relevant to the physical and institutional conditions and lay the foundation of digitalization. The consumption/application side of governance digitalization is involved with many e-regulations like an online public consultation and government service. These elements are the application of digital technologies to create a more favorable and convenient environment for business and the public.

## Understanding the Status Quo and Trend of China's Digitalization

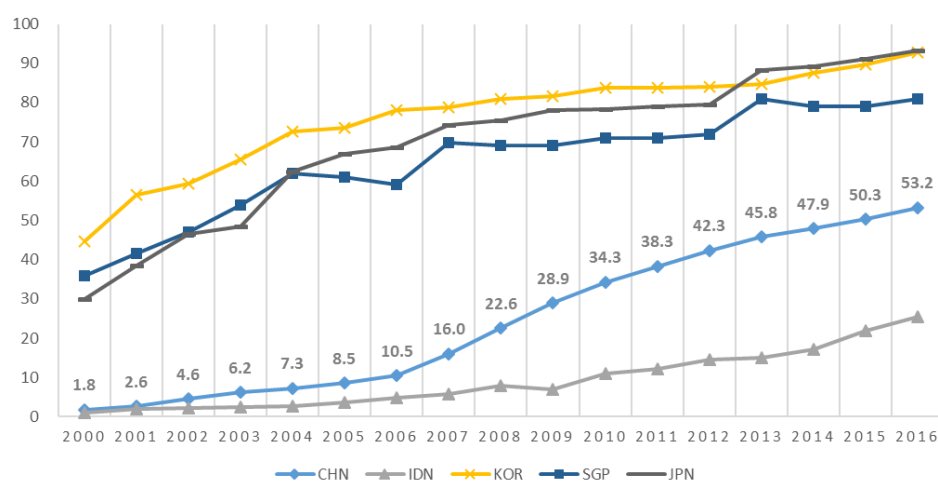
### The Progress of China's Digitalization in the New Round of Digitalization

In the 1990s, China developed its ICT sector with the average speed that is four times the world average (Heshmati and Yang, 2006). Due to the fast development of ICT industry and cheap labor force, China became

the world's largest ICT exporter as the world factory, having overtaken Japan and Europe in 2003 and the United States in 2004. However, there was still a huge gap between China and developed countries regarding ICT innovation and utilization. In order to remedy the gap and grasp the opportunity of digitalization to reshape the economic growth momentum, China recognized the significance of the Fourth Industrial Revolution and embraced the new round of digitalization with great passion. On the one hand, private sectors played a more significant role in the new round of digitalization. The statistic showed the angel capital investment increases to RMB 14.7 billion yuan in 2017 from RMB 1.22 billion yuan in 2013, with a considerable proportion being from the private sectors. On the other hand, the government formulated the national strategies on big data and Internet Plus and formulates regulatory rules for emerging industries in keeping with the principle of encouraging innovation and conducting regulation in a tolerant and prudent way. The favorable regulation atmosphere ignited the prosperity of digitalization in areas like transportation and accommodation, with many unexpected digital applications and new types of business springing up.

China's digital transformation can be analyzed through digitalization matrix. In terms of factor transformation, China exhibits primary progress in ICT usage due to the improvement of digital infrastructure and the decreasing cost of ICT services. At present, China has the world's most extensive mobile broadband facilities and optical network, and is also the world's largest mobile Internet market, with Internet user penetration rate surging from 1.8% in 2000 to 55.8% in 2017, around nine percentage points higher than the world average. On the other hand, digital talents are still in severe shortage in China. The existing education system fails to keep up with the changes in technology and market demand. Currently, more than 85% of China's digital talents are distributed in product development, while the proportion of talents capable of working in advanced manufacturing, digital marketing, and other functions add up to less than 5%.

**Fig. 1 The Internet User Penetration in China and Some Asian Economies**



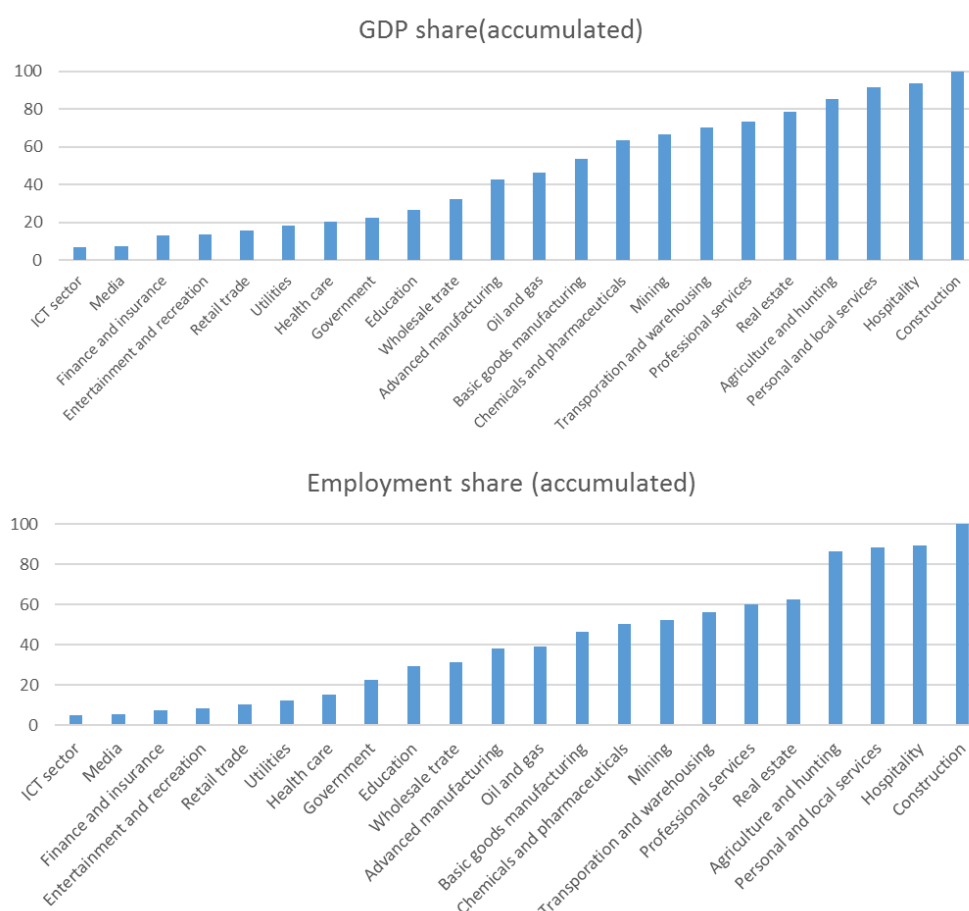
Data source: World Bank.

Note: Internet user penetration is the percentage of Individuals in the population using the Internet.

In terms of industrial digitalization, thanks to the advantages of being close to users, e-commerce has made the digitization of consumption and trade at the forefront of industry transformation. Under this wave, Internet businesses such as Alibaba, Tencent, DiDi, JD and MI emerged, forming an industrial ecology and entrepreneurial community. They provide cloud services and big data processing capabilities for a large number of SMEs, helping

companies to digitize R&D and manufacturing. However, since most manufacturing industries are still in the phase of Industry 2.0 or the transition phase to Industry 3.0, China’s industry still lags far behind in the digital transformation of R&D, design and manufacturing links. McKinsey’s analysis of the digitization levels of 22 industries in China shows that the digitization levels of the top three industries are 6.5 times that of the last three, which shows a more significant gap than many other developed economies. The accumulated share of GDP and the employment of the most digitalized ten industries in China are also less than 40% and 20% respectively, a moderately lower ratio compared to western counterparts.

**Fig. 2 The Accumulated Share of GDP and Employment in China**



Data source: MGI.

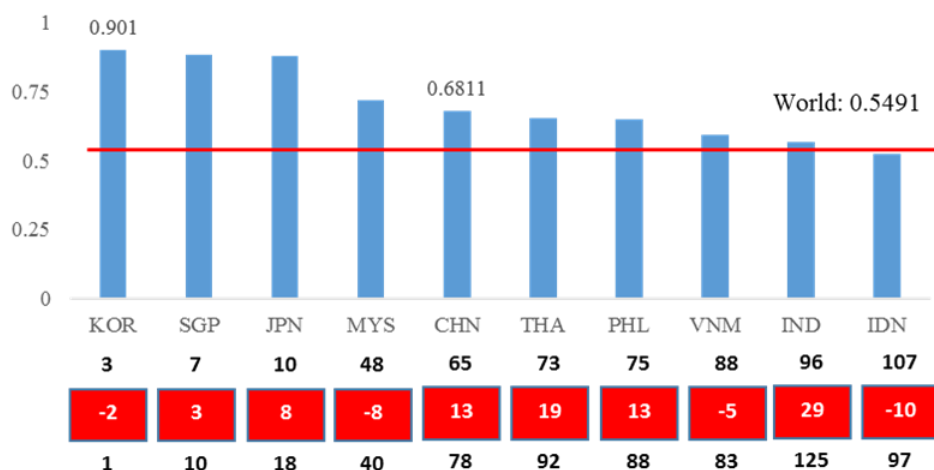
Note: I arrange the industries according to their level of digitalization. ICT sector has the highest level of digitalization while the construction is in the lowest level. The bar represents the accumulated share of GDP (the top) and the employment (the bottom).

In terms of governance transformation, digital services that are most directly related to consumer demand are progressing more rapidly, including e-government, public consultation through network channels, and digitization of community services. At the same time, the government also attaches great importance to platform regulation and takes many measures in maintaining market order and protecting consumer rights and interests. The UN survey indicates China obtains noticeable improvement in e-government in 2018, with the ranking jumping 13



places from the 78th in 2012 to 65th in 2018 among more than one hundred countries. Nevertheless, according to a 2015 survey by a Chinese internet security organization, 44 percent of Chinese websites had security vulnerabilities that led to data leakages. In an annual report released by the Chinese Cybersecurity Emergency Response Team (CN-CERT), the Chinese National Vulnerabilities Database archived 16,000 security vulnerabilities, a 47.4 percent uptick from 2016. It suggests the production/physical side in governance digitalization in China is relatively weak and vulnerable.

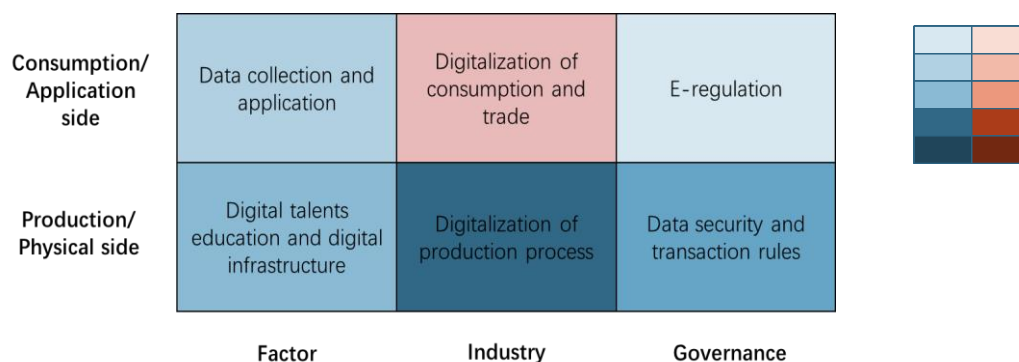
**Fig. 3 The E-government Index of Major Asian Economies and Its Ranking Change**



Data source: UN E-government Survey 2018.

Note: The bar and line represent the E-government index of major Asian economies in 2018. The number in the red box is the ranking change in 2018 compared to that of 2012.

Overall, although China's digital transformation has been steadily unfolding, the main progress happens on the consumption/application side rather than the production/physical side. For example, due to the emergence of digital giants like BAT (namely Baidu, Alibaba, and Tencent) and the prosperity in e-commerce, it is widely recognized that China represents one of the leading and critical forces in digitalization globally. The vast market demand has stimulated the booming development of China's digital economy, but it also causes the digital transformation to concentrate on the consumer end and the application end. Zhang (2018) compared the digitalization between China and South Korea, finding that China only gained a prominent advantage over South Korea in terms of digitalization of trade and consumption but lagged far behind South Korea in digitalization in the process of manufacturing. More specifically, China accounts for a more significant portion of export in ICT goods than that of South Korea. Also, almost 23% of total Chinese retail sales are relative to e-commerce in 2017, just seven percentage points higher than that of South Korea. However, the robot density in China is 68, just around one-tenth of it is in South Korea. Concerning the ICT manufacturing and services expenditure on R&D as a percentage of GDP, the level of South Korea is four times higher than that of China.

**Fig. 4 Colored digitalization matrix using data from China and South Korea**

Source: Zhang (2018).

Note: The element in red represents China has more advantage in that area, and the blue ones indicate the opposite situation. The darker the color implies the more sizeable relative gap of digitalization exists between China and South Korea.

### The Trend of China's Digitalization: Favorable and Challengeable Factors

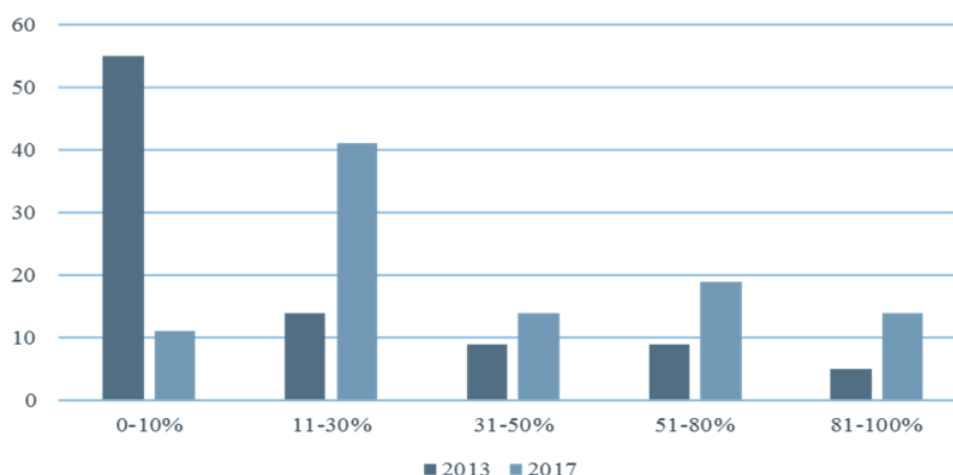
Considering the status quo of digitalization in China depicted above, we can conclude that China's digital dividend is yet to be released. Given that intelligent information technology has a greater potential on the production/physical side, we can expect the digital transformation in China that will move towards the production/physical side from the consumption/application side in the following decades.

Regarding factor transformation, the continuously rising industrial demand will become an essential driving force for the cultivation of digital talents. At present, the demand for talents in China's AI area is growing rapidly, and primary research talents become the main demand point. According to relevant data, there are more than 1.9 million professional and technical talents in the area of artificial intelligence in the world, and the number of personnel engaged in artificial intelligence in China is only 50,000 which is less than 6% of that in the United States, ranking the 7th in the world. Currently, some leading digital enterprises in China have launched collaboration with Chinese universities to develop and cultivate cloud computing and data science workers by sharing digital resources. In addition, the rapid increase in data volume and the maturity of the data-driven business model will make enterprises focus on the application and development of data. The emergence of unmanned driving and smart factories will force the infrastructure to upgrade continuously. Therefore, more digital infrastructure will be set up to improve the availability of ICT infrastructure and individuals' access to basic ICTs.

In respect of industry transformation, based on three aspects of factors, the digital transformation extending to the production/physical side will become the focus of future transformation. First, the decrease in the amount of labor force and the increase in labor costs have become a long-term trend. China's labor participation rate has been in a downward channel for nearly two decades. According to UN predictions, the proportion of people aged at and above 65 in China will rise from 9.7% in 2015 to about 14.1% in 2025, and the working-age population aged 15-64 will be reduced to about 996 million by 2025. The decline in the amount of labor force and the increase in the demand for skilled workers will inevitably lead to a continuous increase in labor costs, which will

force businesses to increase their digital transformation investment in the link of manufacturing. That is why more enterprises in China have prepared to deploy the clouding service and manufacturing robots. Second, the requirements of enterprises and society for quality control in the future will be significantly improved. The Chinese economy will put more emphasis on quality in the future, which will accelerate the use and deployment of intelligent control technology in the source links of industrial and environmental areas, thereby accelerating the digital transformation on the production/physical side. Third, the demonstration effect of the digital ecosystem and the low-cost benefit will be more obvious than ever before. Currently, some industry leading enterprises have already gained revenue in the digitization on the production side, and product turnover rate, defective product rate and supply chain efficiency have also significantly improved. According to the survey launched by the Deloitte in 2017, Chinese enterprises experienced the increasing contribution of smart manufacturing to profit in the past few years (Fig. 5). More than half of the interviewed enterprises reported the contribution of smart manufacturing to firm's profit was less than 10% in 2013. However, in 2017, more than 40% of the interviewed enterprises argued the contribution of smart manufacturing to firm's profit lied in the range from 11% to 30%. In addition, with enterprises having more economic ways to achieve "digital twin," this will substantially lower the threshold for small, medium-sized and micro industrial enterprises to achieve digital transformation.

**Fig. 5 The Increasing Contribution of Smart Manufacturing to Profit**



Source: Deloitte (2018).

Note: The vertical axis represents the percentage of interviewed enterprise and the horizontal axis the range of contribution of smart manufacturing to profit.

In terms of governance transformation, as social governance becomes more complex and users' privacy awareness stronger than it was in the past, it is likely that governance transformation in data property rights, transaction rules, and data security will be accelerated in the future. However, since the governance of the digital economy is restricted by the national conditions of each country, plus some issues still require a long time of discussion, transformation in this regard will be relatively slower. Consumers are also beginning to pay more attention to data security and privacy protection, but this link still faces particular challenges. As the theory and practice of digital governance are still in the research and exploration stage, issues such as transaction rules and data property rights are still in the discussion.

Besides the positive factors in the three dimensions of digitalization mentioned above, we can also identify

the possible internal and external challenges. As for the internal aspect, we have to cope with the problems like incompatibility in the supply and demand, the asynchronicity of digitalization between upstream and downstream industries, and the asymmetry development in institutional system and infrastructure. In addition, as more unreasonable restrictions will be imposed in technology acquisition, market access and the flow of talents in the name of national security, US measures in the trade conflict with China, the main source of external challenge, will also produce the sustained negative impact on the digitalization in China.

## The Implication of China's Digital Transformation for the Asia-Pacific

The financial crisis in 2008 marked the watershed of the world economy. Since then, many economies in the Asia-Pacific suffered from the sluggish growth for rather a long period. In the meantime, the growth rate of global trade was also in the downlink channel. In order to find the new engine of the economic growth, many countries expect the revolutionary progress in the ICT development can reshape the economic momentum and have their eyes on the development of the digital economy in order to achieve innovative economic growth. Until now, a large part of countries in the Asia-Pacific has formulated the policies and launched the initiatives to expedite the digitalization. Even the country like South Korea that plays a leading role in digitalization, it still adopts a series of measures to promote the quality of digitalization. For example, the government passed the Growth through Innovation Investment Plan indicating that 5 trillion won will be invested in 2019 to boost innovative growth, with around 1.5 trillion won invested in the development of digital platforms and 3.5 trillion won in 8 pilot projects related to digitalization. Fortunately, the digital economy does not make them disappointed. In the analysis of the digital economy in the United States by BEA, the annual growth rate of the digital economy from 2006 to 2016 was 5.6%, around four percentage points higher than the economic growth rate in the corresponding period. The report released by the Accenture also showed the share of digital economy in GDP increased to 22% in 2015 from 15% in 2005 and predicted the ratio would hit 25% in 2020.

However, digitalization is not an easy journey for all the Asia-Pacific economies. As smart digital technology has the stronger property of the ecosystem than the traditional ICTs and its broad applications emphasize the growing significance of the role of data and platform, the potential of smart manufacturing, and the necessity to improved digital governance, the digital economy may have a profound impact on the competitive landscape in the Asia-Pacific.

On the one hand, it is unavoidable that the digital economy will become a force to spark differentiation among the regional economies. In essence, digital economy drives the economic growth through digitalization which improves the production efficiency and national competitiveness. In the process of digitalization, a large amount of capital has to be invested in the fields such as high-speed broadband, data storage, and algorithm application. In addition, the success of digital transformation heavily relies upon the availability of data resources and the capability to use them. It means some underdeveloped and developing countries have to face extra challenges besides the lack of capital. For the developed countries, as the smart digitalization in manufacturing is possible to restructure the existing international production network because it will reshape the comparative advantages in trade between developed and developing countries, the developed ones may regain their advantage in manufacturing. Therefore, the new digital divide among countries with different development levels may

exacerbate the existing gap in development.

On the other hand, digital economy may provide incentives and opportunities to strengthen economic cooperation. It is no doubt that profiting from innovation is the ultimate incentive for any entities regardless of what the type of innovation is and what the tool we utilize. In the era of the digital economy, the value-capture problem for innovators in the digital economy involves some different challenges from those in the industrial economy, with the dynamics of platforms and ecosystems being important (Teece 2018). Thus, we should create an open, inclusive, diverse, and fully interactive ecosystem based on the platform in order to take advantage of the network effect, scale effect, and the economy of scope. Furthermore, smart digital technology enables us to realize the instant interaction and self-adaption to eliminate the uncertainty, which lowers the threshold of regional cooperation for SMEs and underdeveloped economies. The incentive and opportunities brought by the digitalization will have prominent influences on regional integration through digital trade and logistic facilitation. Considering the limited scale of market and lack of access to the international market for some economies in the Asia-Pacific, it is somewhat difficult for them to exploit the opportunities of economic cooperation.

The unique advantage that China possesses may suggest that China's digitalization can be an opportunity for the Asia-Pacific to cope with the impact of the digital economy mentioned above. As the second largest economy and the growing mid-class, China owns one of the most huge and promising markets with increasing potential all over the world. Also, China regards the digitalization as one of the top priorities to achieve the quality-oriented economic development. Especially in recent years, the new round of digitalization stepped into a new stage, aiming to speed up digitalization towards production/physical side. The significant improvement in digitalization in the dimensions including factor, industry and governance demonstrate China can help the other economies to overcome the sustained challenges in digital transformation and leverage the opportunities regarding economic cooperation. For example, China has established various funding mechanisms like AIIB, Silk Road Funds, and other long-term cheap loans, all of which can support the construction and interconnection of digital infrastructure. The Chinese digital giants like BATJ (namely Baidu, Alibaba, Tencent, and JD) can also play a more significant role in facilitating cross-border e-commerce in many ASEAN countries. Even in the clouding service, Alibaba is competent to build an ecosystem including more than 8,000 companies and meet their demands in time with its leading technologies. Among over a thousand smart city pilots have been launched across the world, China is home to half of these cities, amounting to a staggering 500 pilots. It provides significant opportunities for the Asia-Pacific economies with leading capabilities in this aspect to profit from their leading technologies and abundant experiences through a mechanism such as PPP contract.

Considering China's digitalization can be regarded as an opportunity for the Asia-Pacific, I strongly recommend the economies in the Asia-Pacific should enhance cooperation on digital economy by leveraging China's digitalization. I refer to the APEC Internet and Digital Economy Roadmap which is released in 2017 and select the promising areas including (1) Development of digital infrastructure; (2) Development of holistic government policy frameworks for the Internet and Digital Economy; (3) Promoting coherence and cooperation of regulatory approaches affecting the Internet and digital economy; (4) Promoting innovation and adoption of enabling technologies and services; (5) Enhancing inclusiveness of Internet and digital economy; and (6) Facilitation of e-commerce and advancing cooperation on digital trade. ■

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## Author's Biography

**Mingshen Zhang** received his doctoral degree from Renmin University of China in 2014 and served as the assistant research fellow in Institute of Economic Research, National Development and Reform Commission since 2015. His research interests concentrate on innovation and entrepreneurship such as technology transfer and commercialization. His work has been published in multiple journals, including *Research Policy* and *Macroeconomic Research*. He is also the author of the book, entitled *Open Innovation of China's Firms and Performance Implication within the Context of Structural Reform* (2017).

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