

Measurement of the Digital Level of Chinese Producer Services and its Development and Evolution Law

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Abstract: Using the national input-output table data from 2002 to 2017, this paper calculates the digital level of China's producer services from the perspective of the dependence of producer services on ICT industry, and analyzes its evolution law. The results show that the digital level of producer services in China shows a downward trend in the sample period. Although the structure of digitization of producer services in China is still in its infancy, its structural optimization trend is obvious. At this stage, leasing and commercial services, scientific research and technical services mainly rely on ICT manufacturing product factor investment to achieve digital development, while the financial sector is just the opposite. Whether from the perspective of dependence on ICT manufacturing industry or ICT service industry, the digital transformation of China's transportation, warehousing and postal departments appears underpowered.

Keywords: Producer services; Industrial digitization; Digital level measurement.

1. Introduction

As an intermediate input, producer services run through many links of enterprise production activities, and its high-end position in the value chain has further prompted many countries to take it as a key development industry, so as to quickly become the fastest-growing department in the economic system. In contrast, although China's large-scale industrialization process provides a favorable opportunity for the development of producer services, up to now, its development level is still low in terms of total amount and quality, which does not match the overall level of China's economic development. Therefore, the relative lag in the development of producer services has become a key short board restricting the optimization of China's industrial structure, the transformation of development mode and the transformation of old and new kinetic energy.

One of the connotations of digital economy is industrial digitization. The producer service industry dominated by financial services, information services, R&D and scientific and technological services has the characteristics of knowledge intensive, technology intensive, information intensive and talent intensive (Li Ping. et al,2017), so it has the natural advantage of rapidly realizing the digital transformation of the industry. China's agricultural digital economy and industrial digital economy account for only 7.3% and 18.3%, while the digitization of service industry accounts for 35.9%. Therefore, it will become an important strategic choice for China to pay close attention to the important window period of the digital revolution, rely on the rapid development of the digital economy and make up for the shortcomings of the producer service industry. So, what is the digital development level of producer services in China? What laws exist in its evolution process? The research on these problems is not only a useful summary of the digital development experience of China's producer services industry, but also provides new ideas and data support for the research on digital economy.

2. Literature Review

With the continuous expansion of the scale of digital economy and its increasing importance in the national economy, the index construction and measurement of the development level of digital economy need to be solved urgently. Mesenbourg(2001) relied on e-commerce as a measure of digital economy. Haltiwanger and Jarmin(2000) used e-commerce, information technology infrastructure, demographic and worker characteristics, enterprise and industry structure and price behavior data for evaluation. OECD research mainly considers two indicators: digital economy infrastructure (ICT sector) and digital economy output (E-commerce and Internet Economy). In recent years, domestic institutions and scholars have increasingly enriched their research on the measurement of China's digital economy development level and its development law. Based on the development status and characteristics of digital economy, China Academy of information and communication(2017) selected relevant indicators from four levels: macro economy, basic capacity, basic industry and integrated application to build a digital economy index (DEI) index system. Liu Jun et al.(2020) defined the connotation of digital economy as a new economic form that takes digital information as the core element, takes the development of informatization and Internet as the support, provides products or services through digital technology, and enables producers and consumers to conduct digital transactions Build the evaluation index system of digital economy in China's provinces from the three dimensions of Internet development and digital transaction development. On this basis, Zhao Tao(2020) combined with the availability of relevant data at the city level, constructed an index system only from the two dimensions of Internet development and digital financial inclusion to calculate the comprehensive development level of digital economy in Chinese cities. Wang Jun et al.(2021) the index system for measuring the development level of China's digital economy should include four first-class indicators: digital economy development carrier, digital industrialization, industrial digitization and digital economy development environment.

Jiao Shuaitao and Sun Qiubi(2021) constructed a comprehensive evaluation index system of China's inter provincial digital economy from the four-dimensional perspectives of digital foundation, digital application, digital innovation and digital transformation.

In conclusion, the basic ideas of domestic and foreign scholars on the construction of digital economy index system are the same, that is, the evaluation index must be reasonably designed based on the definition of the connotation of digital economy, combined with the research needs and data availability. However, because scholars' research focus and understanding of the connotation of digital economy are different, their calculation results are often quite different. Industrial digitization is an important part of digital economy, but the existing research rarely involves the measurement of industrial digitization level. Therefore, the marginal contribution of this paper lies in: a. emphasizing the importance of the digital development of producer services, providing a new perspective for the research of digital economy; b. According to the connotation of "industrial digitization" in digital economy, from the perspective of the dependence of producer services on ICT industry, this paper puts forward the calculation method of the digital development level of producer services, so as to provide data support for the research related to industrial digitization; c. This paper analyzes the development and evolution law of the digitization of producer services in China, summarizes the experience and shortcomings, and provides decision-making basis for the development planning of digital economy.

3. Calculation Method and Data Source

3.1. Calculation Method

Information and communication technology (ICT) is closely connected with digital economy. When Tapscott (1996) first proposed the concept of "digital economy", he pointed out that digital economy describes an economic system that widely uses ICT technology. In this system, digital knowledge and information are taken as key production factors, and the effective use of ICT technology is taken as an important driving force for the improvement of production efficiency and the optimization of economic structure. Therefore, as an important part of digital economy, industrial digitization is to widely apply ICT technology to traditional industries, so as to reduce production costs and improve production efficiency (Xu Xianchun and Zhang meihui, 2020). Therefore, this paper intends to measure the

digital development level of producer services from the perspective of the dependence of producer services on ICT industry.

Hypothesis y_i is all intermediate inputs directly consumed by the i th Department of producer services in production and operation, x_{i1} and x_{i2} represents the quantity of ICT manufacturing and ICT service products directly consumed by the Department, then $x_i = x_{i1} + x_{i2}$ represents the total amount of ICT products directly consumed by the Department. So, $a_{i1} = x_{i1}/y_i$ and $a_{i2} = x_{i2}/y_i$ represents the dependence of the i th sector on ICT manufacturing and ICT Service Industry (direct consumption coefficient), $a_i = x_i/y_i = a_{i1} + a_{i2}$ can be used to measure the digital development level of the Department. If producer services include n sectors, the dependence of producer services on ICT manufacturing can be expressed as

$$A_1 = \frac{\sum_i^n x_{i1}}{\sum_i^n y_i}$$

The dependence of producer services on ICT manufacturing can be expressed as

$$A_2 = \frac{\sum_i^n x_{i2}}{\sum_i^n y_i}$$

$A = A_1 + A_2$ indicates the total dependence of producer services on ICT industry. The greater A , the greater the importance of products and services from ICT industry to the production and operation of producer services. Therefore, it can reflect the digital development level of producer services to a certain extent.

3.2. Data Sources

The data used in this paper are from seven national input-output tables from 2002 to 2017. In order to distinguish it from ICT industry, this paper defines producer services as "transportation, warehousing and postal", "finance", "leasing and commercial services" and "scientific research and technical services". In addition, inspired by Guo Meichen and Du Chuanzhong (2019), this paper defines the ICT industry as "communication equipment, computers and other electronic equipment" and "information transmission, software and information technology services", in which the former represents the ICT manufacturing industry and the latter represents the ICT service industry. The numbering range of the above six departments in the national input-output table of each year is shown in Table 1. The indexes involved in this paper are relative values, so the input-output data are not subject to constant price processing.

Table 1. Numbering range of six departments in the input-output table of each year

Department	Years						
	2002	2005	2007	2010	2012	2015	2017
Transportation, storage and postal service	51090-59099	27-28	096-104	27-28	53104-60111	30	53107-60118
Finance	68105-70106	32	111-112	32	66116-68118	33	66126-68128
Leasing and commercial services	73108-74109	34	114-115	34	71120-72121	35	71130-72131
Scientific research and technical services	75111-78113	35-36	118-120	35-36	73122-75124	36	73132-75134
Communication equipment, computers and others	40075-40080	19	082-087	19	39086-39091	20	39088-39092
Information transmission, software and information technology services	60100-61101	29	105-107	29	63114-65115	32	64123-65125

4. Analysis of Calculation Results

As shown in Table 2, from 2002 to 2010, the dependence of China's producer services on ICT industry decreased continuously from 0.112 to 0.054. Although the index rebounded slightly in 2012 and 2015, the total dependence of producer services on ICT industry decreased by 19.34% in 2017 due to the sharp decline in the dependence of producer services on ICT manufacturing industry in 2017. This shows that the digitization level of China's producer services industry generally shows a downward trend, with a significant decline in 2007 and 2017. The reason is that with the acceleration of China's urbanization and industrialization, the scale of producer services continues to expand, and the corresponding amount of intermediate investment increases rapidly. However, in the early stage of the development of producer services, there is no need for digital factors to participate, and only the input of traditional factors can improve productivity. Therefore, the input of traditional intermediate products in China's producer services in 2017 increased by 13.34 times compared with 2002, while the input of ICT intermediate products in the same period increased by only 5.48 times. Especially during the international financial crisis and after China's economy entered a new stage of development, the active fiscal and monetary policy and the policy orientation of economic structure transformation and upgrading have further increased the scale of traditional factor investment in producer services, while the corresponding digital factor investment has not increased but decreased. Among them, the investment in ICT intermediate products

decreased by 32.04% in 2007 and 3.02% in 2017 compared with 2015. Therefore, at this stage, the development of China's producer services industry still mainly depends on the traditional factor driven model, rather than the digital factor driven model.

From a horizontal perspective, in the annual composition of China's producer services' dependence on ICT industry, producer services' dependence on ICT manufacturing industry accounts for a relatively large proportion, while its dependence on ICT service industry accounts for a relatively small proportion. This is significantly different from western developed countries. According to the estimates of Li Jiangfan and Zhu Ming (2016), the dependence of producer services in the United States, the United Kingdom and Japan on ICT services accounted for 76.7%, 78.5% and 93.6% respectively in 2011. This shows that the digital structure of China's producer services industry is still in its infancy, and its development mainly depends on the input of ICT manufacturing product factors, rather than driven by ICT service product factors. Vertically, the dependence of China's producer services on ICT services has increased from 35.23% in 2002 to 49.00% in 2017. At the same time, the input of product factors in ICT services increased from 55.574 billion to 423.606 billion in 2017, an increase of 7.62 times, while the input of product factors in ICT manufacturing increased by only 4.32 times in the same period. All these show that although the absolute level of dependence of China's producer services on ICT services is low, its relative changes are obvious. Therefore, it can be considered that the digitization of China's producer services has entered the development channel of evolution from low-level to high-level.

Table 2. Calculation results of digital level of producer services in China

years	A_1	A_2	A	A_1/A	A_2/A
2002	0.0726	0.0395	0.1121	64.77%	35.23%
2005	0.0705	0.0370	0.1075	65.60%	34.40%
2007	0.0390	0.0259	0.0649	60.05%	39.95%
2010	0.0303	0.0233	0.0535	56.54%	43.46%
2012	0.0327	0.0240	0.0567	57.64%	42.36%
2015	0.0370	0.0242	0.0612	60.50%	39.50%
2017	0.0252	0.0242	0.0493	51.00%	49.00%

Note: A_1 indicates the dependence of producer services on ICT manufacturing, A_2 refers to the dependence of producer services on ICT manufacturing industry, and A refers to the total dependence of producer services on ICT industry, A_1/A and A_2/A means a respectively A_1 , A_2 proportion in A .

Figure 1 shows the dependence of the four sectors of producer services on ICT manufacturing. It can be seen that during the sample period, the dependence of leasing and commercial services and scientific research and technical services on ICT manufacturing industry has an obvious downward trend. Although the initial level of leasing and

commercial services is higher, the decline rate is faster, resulting in the dependence of scientific research and technical services on ICT manufacturing industry beyond leasing and commercial services after 2010. The dependence of transportation, warehousing, postal service and Finance on ICT manufacturing industry has changed steadily, but its overall level has always remained around 0, significantly lower than leasing and commercial services, scientific research and technical services. This shows that the digital development of China's transportation, warehousing, postal and financial sectors hardly depends on the input of product elements of ICT manufacturing industry.

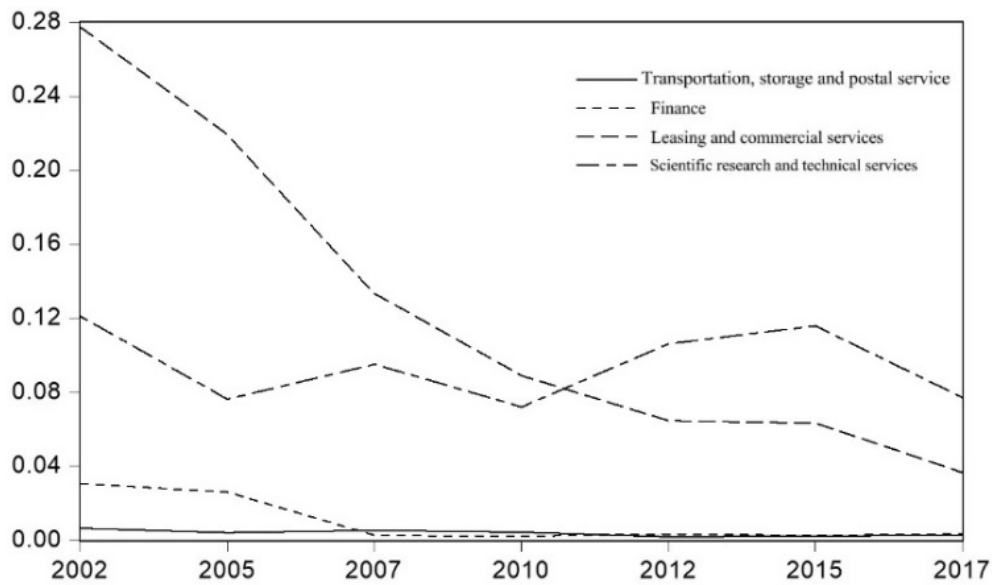


Figure 1. Dependence of four sectors of producer services on ICT manufacturing

Figure 2 shows the dependence of the four sectors of producer services on ICT services. It can be seen that the financial sector is significantly more dependent on ICT services than the other three sectors. Moreover, the dependence of finance, leasing and business services, scientific research and technical services on ICT services shows a downward trend over time, especially from 2005 to 2007. This is consistent with the overall level measurement results of the

digital development of producer services. In addition, although the dependence of transportation, warehousing and postal services on ICT service industry is low as a whole, it changes steadily, and increased slightly from 2005 to 2007, resulting in its lower than leasing and commercial services, scientific research and technical services before 2005, and higher than these two sectors later.

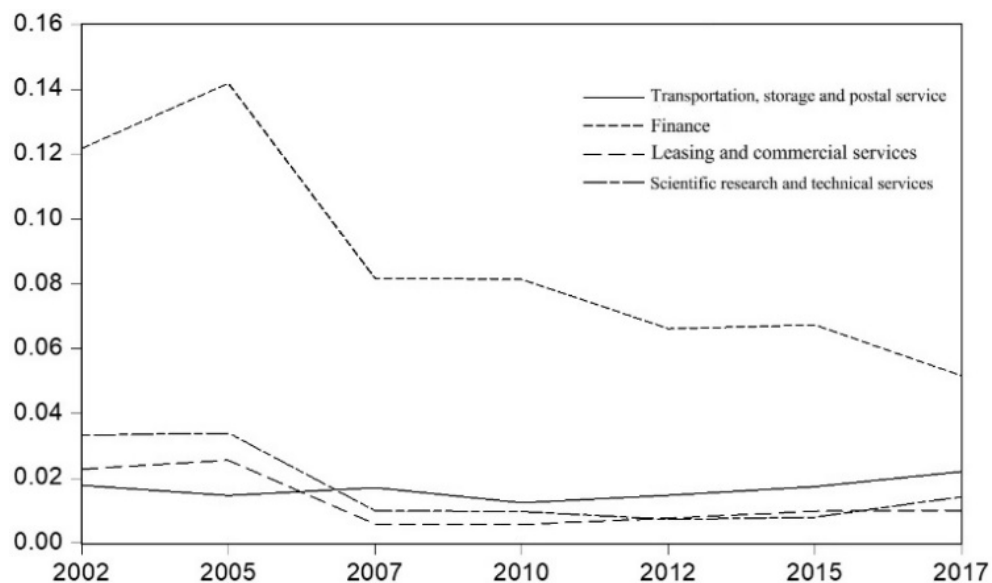


Figure 2. Dependence of four sectors of producer services on ICT Services

According to Figures 1 and Figures 2, in China's producer services, the financial sector has a relatively high dependence on ICT services and a relatively low dependence on ICT manufacturing. On the contrary, the two sectors of leasing and commercial services, scientific research and technical services have relatively high dependence on ICT manufacturing industry and relatively low dependence on ICT service industry. The possible reason is that the entry threshold of China's financial sector is high, resulting in the limited number of new financial enterprises, and the slow update and iteration speed of existing financial enterprises for ICT manufacturing products (hardware products such as communication equipment, computers and other electronic equipment). In contrast, the entry threshold of leasing and commercial services and scientific research and technical

services is relatively low, resulting in more new enterprises participating in market competition, which is bound to expand the demand for ICT manufacturing products. Moreover, the business characteristics of the two departments determine that these enterprises must update ICT manufacturing products faster in order to ensure the survival and development of enterprises. Therefore, at this stage, China's financial sector mainly relies on the input of product elements of ICT service industry to realize digital development, while leasing and commercial services, scientific research and technical services mainly rely on the input of product elements of ICT manufacturing industry to realize digital development. Finally, whether from the perspective of dependence on ICT manufacturing industry or ICT service industry, the digital transformation momentum of China's transportation,

warehousing and postal sectors is insufficient.

5. Conclusions and Policy Suggestions

The digital development of producer services is of great significance to quickly make up for the shortcomings of China's producer services, cultivate new economic growth points and form new driving forces. Based on the data of seven national input-output tables from 2002 to 2017, this paper calculates the digital level of China's producer service industry and analyzes its development and evolution law from the perspective of the dependence of producer service industry on ICT industry. The results show that during the sample period, the digitization level of producer services in China shows a downward trend. Horizontally, the digital structure of China's producer services industry is still in its infancy, and its development mainly depends on the input of ICT manufacturing product factors, rather than driven by ICT service product factors. Vertically, although the absolute level of dependence of China's producer services on ICT services is low, its relative changes are obvious. Therefore, it can be considered that the digitization of China's producer services has entered the development channel of evolution from low-level to high-level. In terms of sub sectors, at this stage, China's leasing and commercial services, scientific research and technical services mainly rely on the input of product elements of ICT manufacturing industry to realize digital development, while the financial sector is just the opposite. However, whether from the perspective of dependence on ICT manufacturing industry or ICT service industry, the digital transformation momentum of China's transportation, warehousing and postal sectors is insufficient.

Based on these conclusions, this paper gives the following policy suggestions: First, we should take the digital economy policy orientation as an opportunity to actively guide the digital development of producer services, promote the application of cloud computing, big data, Internet of things and other information and communication technologies in producer services, and improve the technical content and competitiveness of producer services through the integration of digital elements, Make China get rid of the reality that producer services are in the primary stage of digital development as soon as possible; Second, respect the objective law of different dependence of various departments of producer services on ICT manufacturing and service industries, and formulate differentiated digital development strategies by sectors with the goal of maximizing marginal contribution; Third, for logistics, an industry with weak digital development, we should strengthen the development

of core technologies, focus on promoting the application of cloud computing, Internet of things, geographic information technologies in logistics intelligent management, and strengthen the construction of comprehensive and professional logistics public information platform and cargo loading center, so as to effectively reduce costs and improve efficiency through digital transformation.

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