

Research on the Influence of Digital Economy on the Development Intensity of Manufacturing Industry Chain

-- Based on China's Input-output Panel Data from 1990 to 2018

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Abstract

The digital economy can reconstruct the organizational form of the industrial chain, which profoundly affects the operational strength of the industrial chain. This paper analyzes the internal mechanism of the digital economy affecting the strength of the manufacturing industry chain. Based on China's input-output surface data from 1990 to 2018, it empirically examines the impact of digital hardware facilities and digital software services on the strength of the manufacturing industry chain. The results show that the digital economy can effectively promote the increase in the strength of the manufacturing industry chain; the slow growth of digital hardware facilities inhibits the increase in the strength of the industry chain; and the digital software services will promote the increase in the strength of the industry chain, but the investment in digital software services has an impact on the industry. The development of the chain plays a negative role. The input-output curve of digital software services is in the declining stage of the inverted "U" curve, and there is an urgent need for transformation and development. Therefore, in the future, my country should vigorously promote the high-end development of digital hardware facilities, and at the same time promote the high-quality development of digital software service transformation.

Keywords

Digital Economy; Manufacturing Industry Chain; Panel Data; Empirical Analysis.

1. Introduction

Since 1949, China has established a comprehensive and large-scale industrial system through a "compressed" industrialization method, and has developed from a backward agricultural country to a world-class manufacturing country. However, the outbreak of events such as the ZTE incident and the Huawei incident, especially the change of global competition pattern and the lack of global economic growth since the Covid-19, has made us soberly aware that determinants of economic competition among countries has shifted from products to supply chain. Meanwhile, this series of incidents also deeply exposed the weaknesses and shortcomings of China in the construction of the industrial chain for a long time, implying that the construction of a safe, stable, autonomous and controllable modern industrial chain has become one of the primary tasks of China who pursues high-quality economic growth.

Recently, new products, new services, and new business models supported by digital technology playing a role in building a new development pattern have become important contributors to economic growth under the context of two cycles which incorporate domestic and international cycles. In fact, digital technology is the new engine of industrial development during the new industrial revolution and the main driving force for the development of the digital economy[1]. Big data, cloud computing, artificial intelligence, blockchain and other digital technologies, especially the in-depth integration of digital technology and traditional

industries, have not only become the direction of transformation but also reflected the new industrial organization structure. At the same time, under the influence of digital technology, extensive and profound changes will take place in the technological association, value transfer, spatial layout, and organizational relationships in the industrial chain, which will greatly shorten the information distance between upstream and downstream enterprises and effectively promote the input of production factors. The precise connection with market demand further reduces the space-time distance of technology and knowledge exchanges among enterprises. As a new type of social division of labor and collaboration network relationship, the digital industry chain stands out. It is manifested as follows: 1. Digital technology to drive the extension and transformation of the industrial chain; 2. Development of the industrial chain to promote digital technology innovation[2]. Therefore, in the process of "digital industrialization and industrial digitization" moving towards "digital industry chain", under the logical framework of the digital industry chain, through the dual drive of external market environment and application scenarios changes, the boundaries of the division of labor in the industry chain organization tend to be blurred and the organizational structure tends to be flat, synergistic, and flexible[3].

Technology leadership, value transmission, structural reshaping, and innovation drive are the internal motivations for the formation and development of the industrial chain. The key to improve the modernization level of the industrial chain is to create higher added value, enhance the resilience of the supply chain, and enhance the innovation capability and its digital level. In fact, the industrial chain, value chain, supply chain, and innovation chain are multi-dimensional representations of the integration of social division of labor and collaboration networks. Digital technology, through the multi-chain integration of the industrial chain, value chain, supply chain, and innovation chain, helps to promote the networked and coordinated development of the industry, and promotes linkage, competition, coordination, and cluster evolution, forming the network relationship that penetrates into each other and dynamically and flexibly adapts to market changes under the expression of the hierarchical chain [4]. Therefore, the process of multi-chain integration of the digital industry is also a process of industrial chain linkage, value chain competition and cooperation, supply chain collaboration, and upgrade of innovation chain cluster. In particular, digital technologies represented by 5G, Internet of Things, big data, cloud computing, blockchain, artificial intelligence, machine learning, digital twins, virtual and augmented reality, etc., can effectively promote the tracking management of the digital industry chain, enhancing the core technology control power of the entire industry chain, and then achieve the goal of independent controllable, safe and stable, and efficient operation[5]. In this regard, in the new stage of high-quality development of China's economy, improvement of the overall modernization of the digital industry chain and enhancement of the independent controllability of the digital industry chain will not only provide relevant enterprises with the industry chain, value chain, and supply chain in the entire operation process but also further enhance the national competitive advantage and the international competitiveness of the industry in the process of adjustment of the global digital industrial chain[6].

The digital economy has given the industrial chain new vigor and characteristics of the times. It is of great practical significance to examine and study the strength of the industrial chain from the perspective of the digital economy. However, the digital and intelligent transformation of the manufacturing industry chain is not a one-day effort. How can we effectively use the digital economy to empower the transformation and upgrading of the manufacturing industry? How much influence does the digital economy have on the development of the manufacturing industry chain? These issues urgently need to be further studied. The digital economy has given the industrial chain new vigor and characteristics of the times. It is of great practical significance to examine and study the strength of the industrial chain from the perspective of the digital economy. However, the digital and intelligent transformation of the manufacturing

industry chain is not easy. How can we effectively apply the digital economy to empower the transformation and upgrade of the manufacturing industry? How much influence does the digital economy have on the development of the manufacturing industry chain? These issues urgently need to be further studied.

2. Literature Review

Under the background of the era when the division of labor within products occupies a dominant position, the industrial chain has become the basic unit of today's organization of production and plays a fundamental role in the operation of the economic system. As the digital transformation and upgrade of the industrial chain have become the subject of a new round of industrial revolution, research on the digital economy and industrial chain has gradually attracted the attention of the academia and industry.

The world has entered the stage of the fourth industrial revolution centered on the integration of the Internet of Things, the Internet of Services, and the manufacturing industry. Compared with the previous three industrial revolutions, the fourth industrial revolution involves more extensive fields and more advanced technologies, among which the digital economy is the most important feature and digital technology is the core. The concept of the digital economy first was proposed by Don Tapscott (1996), and in 1998 the "Emerging Digital Economy" report issued by the U.S. Department of Commerce was shown up, indicating this concept was officially established. With the iterative development of smart phones and the rapid development of the mobile Internet, the digital economy has entered its golden age. However, a clear definition of the digital economy has not yet given by researchers. Most scholars believe that digital technology is the main component of the digital economy. Guan et.al (2020)[7] believe that the digital economy includes digital equipment manufacturing, digital information transmission, digital technology services, digital content and media, Internet applications and related services. Bukht and Heeks (2017) [8] believe that the core of the digital economy is the digital sector, and the main part or all of economic output comes from digital technology. Pei et al. (2018)[9] consider that the core driving factor in the digital economy is data and digital technology has played a decisive role in the production process. From the perspective of economic and social paradigm, Yang et al. (2018) [10] believe that the digital economy is the transformation of the work style of labors and consumers' daily life dominated by digital technology into an economic and social paradigm represented by digital access. Liu (2003)[11] holds that the difference between the digital economy and the traditional economy is that the digital economy is an innovative, speed-oriented, human-oriented, virtual and globalized economy from the perspective of development characteristics. Governments all over the world also attach great importance to the development of the digital economy, and give different connotations to the digital economy. At present, the new generation of information technology represented by the Internet, big data, cloud computing, etc. is skyrocketing. Informatization, as core of digital economy, has penetrated into many areas of the economy and society, leading technological revolution and industrial transformation and affecting the pattern of global competition.

The industrial chain is a kind of resource, which reflects the scale effect of industrial agglomeration. Digital technology well reduces the asymmetry of information in the competition and cooperation of the main players in the industry chain, breaks the traditional closed operation mode, optimizes production operations and management, and improves operational efficiency and output benefits. Driven by digital technology, the industrial chain can extend in both vertical and horizontal directions. Yu and Li (2021)[12] point out that the vertical extension of the industrial chain is the process of direct extension or reverse extension from upstream raw materials, energy base, and production links to downstream intermediate products and finished products industries while the horizontal extension of the industrial chain

refers to the extension of a certain link of the industrial chain to its supporting related industries, through business expansion, horizontal mergers and acquisitions, digital integration and other channels to engage in research and development. Digital technology is the main driving force for the formation and development of the digital economy, and the development of the digital economy can provide support for industrial transformation and upgrading. Under the impact of the COVID-19 in recent years, the digital economy industry chain has shown a trend of deepening, differentiation, and rupture of the digital industry chain. Europe and the United States continue to block the import and export of digital technologies and products and equipment causing long-term negative impacts on the global division of labor and layout of China's digital industry chain, which deserves the government and enterprises' attention (Liu and Xu, 2021)[13]. Under the current new development pattern, the internal and external environment of China's industrial chain has undergone major changes. When the current international division of labor system puts developing countries on the "periphery" and at the low end of the industrial chain, China's industrial chain has entered a period of local strengthening. It should focus on strengthening localization, enhancing independent controllability, and accelerating the advancement of the industrial chain, Digitization, Openness, High-end Branding (Gao and Zhang, 2021)[14].

The industrial chain is a dynamic development concept. With the development of the economy, the industrial chain also presents new features and generates new problems, which leaves a room for improvement in existing research. (i) Under the background of the digital transformation of the industrial chain, the researches on the digital economy and the industrial chain lack empirical studies; (ii) The strength of the industrial chain is an important issue that China is now facing, but from a quantitative perspective, there is almost no literature that studies this issue. The contributions of this paper are as follows. (i) We theoretically analyze the influence path and internal mechanism of the digital economy on the strength of the industrial chain, and expand the value and significance of existing research results in the new economic form; (ii) Digitalization hardware facilities and I software services are used to empirically test the impact of the digital economy on the strength of the industrial chain, and compare the differences in the impact of the two on the strength of the industrial chain; (iii) In the process of empirical testing, we consider the impact of the time factor, which provides a theoretical basis for the government to improve relevant policies.

3. Mechanism Analysis and Research Hypothesis

The development of a new generation of information technology has promoted the in-depth integration of digital technology and the real economy, and has caused the digital reconstruction of industrial organizations. The digital industrial chain affects the development intensity of the industrial chain through the four dimensions including enterprise chain, value chain, supply chain and innovation chain[15].

3.1. The Digital Economy Strengthens the Stability of the Enterprise Chain

The enterprise chain is the representation of the industrial chain, that is, the supply-demand relationship, the spatial relationship and the value relationship in the industrial chain are realized by relying on the enterprise chain. Once the enterprise chain is interrupted, the rest of the chain will have to face the risk of breaking. The digital economy strengthens and enhances the stability of the enterprise chain through network effects and synergy effects [16]. On the one hand, the improvement of the level of corporate digitalization can enhance the cohesion of the Industrial Internet. The higher the digital level of the enterprise chain, the lower the cost and threshold for joining the Industrial Internet. According to Metcalfe's Law, the more companies that participate in the Industrial Internet, the greater the value they obtain from the Internet, and the stronger the cohesion of the Industrial Internet, thus ensuring the stability of

the enterprise chain. On the other hand, the improvement of enterprise digitization can improve the synergy efficiency of the enterprise chain. The higher level of digitization of the industrial chain means that information exchanges between enterprises are faster and more convenient, and the integration of knowledge and technology is less difficult, which means that enterprises can quickly capture the uncertain factors in the industrial chain and react to maintain their relationship with each other [17].

3.2. The Digital Economy Promotes Synergy in the Supply Chain

In the era of digital economy, the extensive application of digital technology has brought about tremendous changes in supply chain management. The supply chain network must be continuously optimized and the process must be consumer-oriented and highly flexible in order to meet the diversification of customers in the fierce competition. Through the supply chain digital technology, it is possible to create process mirroring and provide all supply chain-related business information within the organization, improving the visibility and transparency of the end-to-end supply chain [18].

3.3. The Digital Economy Promotes The Innovation Of The Space Chain

Digital knowledge and information are non-competitive in space and time. With the acceleration of the global digital economy and the gradual emergence of new corporate competition patterns, technology, knowledge, information, capital, talents, and natural resources are developed in the form of networks, which bring new development ideas for competition and cooperation [19]. The focus of the needs of different links in the space chain, the full use of global scientific and technological resources, and the strengthening of research and development in the region, to obtain stronger competitiveness with lower costs and higher efficiency, have become the key to enterprise innovation activities under the new development pattern. In the digital economy era, common technical knowledge such as industry principles, basic processes, business processes, and expert experience can be coded, componentized, and modeled through digital technologies such as industrial software and big data to promote the reuse, sharing, and value reconstruction of industry knowledge [20].

3.4. The Digital Economy Expands The Value-Added Space Of The Value Chain

Under the background that the division of labor in the value chain has become the main division of labor between countries, the development of Chinese enterprises is showing the characteristics of evolving from a single entity to a diversified entity, from a single center to a multi-regional center with optimized value chain layout, that is, the same product The division of labor between different production links within the same production link and different production processes or R&D processes in the same production link. With the continuous development of the digital economy, what needs to be seen is that the increase in the level of digitalization of the global value chain will have different impacts on countries and enterprises in different links of the division of labor [21]. On the one hand, new business models such as e-commerce, online payment, and digital platforms have further strengthened the first-mover advantages of high-income countries and global leading companies. On the other hand, due to changes in the price formation mechanism of elements and products in the value chain of digital technology, leading companies use their own network-monopolized data resources and artificial intelligence and other technologies to carry out more precise pricing and globalization. Optimal matching of market demand and production location can in fact control the pricing power of the global value chain. Companies in the low-end manufacturing link of the value chain will be squeezed from upstream and downstream at the same time, including upstream companies' technology, brand constraints, and downstream price competition. Based on the above analysis, the impact of the digital economy on the industrial chain is a multi-chain integration and progressive process, extending from the enterprise chain to the supply chain,

the space chain, and ultimately the value chain, the enterprise chain, the supply chain, and the space chain [22]. And the value chain has its own the path dependence of the digital economy to enhance the strength of the industrial chain of which the transmission and sharing of data is particularly important, as shown in figure 1. It is an important part of a smooth industrial chain and a key link for the digital economy to enhance the strength of the manufacturing industry chain. Accordingly, this article proposes the following research hypotheses.

H1: The digital economy has a positive effect on the improvement of the strength of the manufacturing industry chain. The higher the digitalization level of the manufacturing industry chain, the greater the development intensity of the manufacturing industry chain.

H2: There are differences in the impact of digital hardware facilities and digital software services on the strength of the manufacturing industry chain.

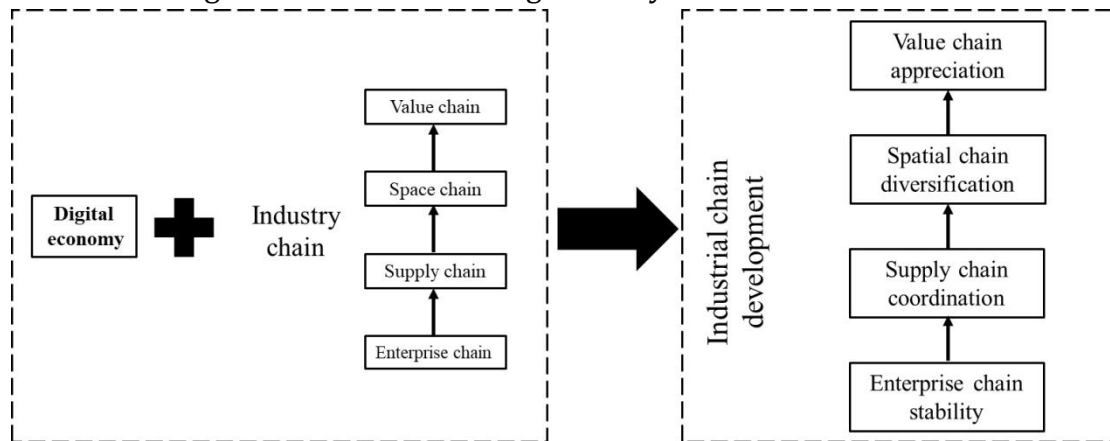


Figure 1. The mechanism of the influence of the digital economy on the industrial chain

4. Research Design

Table 1. Manufacturing Industry Chain

Number	Industrial Chain	Manufacturing Included
1	Food manufacturing and tobacco	C13, C14, C15, C16
2	Textile and apparel	C17, C18
3	Shoes and hats	C19
4	Furniture manufacturing	C20, C21
5	Papermaking and cultural, educational and sporting goods	C22, C23, C24
6	Energy	C25
7	Chemical product	C26, C27, C28, C29
8	Non-metallic mineral products	C30
9	Metal	C31, C32,
10	Metal smelting and rolling processing industry chain	C31
11	Metal products industry chain	C32
12	General equipment industry chain	C34
13	Machinery and equipment manufacturing	C34, C35
14	Transportation equipment manufacturing	C36, C37
15	Electrical machinery and equipment manufacturing	C38
16	Computer, communications and other electronic equipment manufacturing	C39
17	Other manufacturing	C41, C42, C43

Manufacturing is an important part of the real economy and the main battlefield of the digital economy. Therefore, this article focuses on the manufacturing industry chain. Before empirical study, we should trace the complete manufacturing industry chain based on the final product, and screen out the manufacturing industries that can form the final product according to the horizontal product distribution in the input-output table. A total of 17 industry chains are selected, as shown in Table 1. The manufacturing industry codes in the table are from the industry classification Standard of National Economy in 2017 (GB/T 4754-2017).

We use a panel model based on the industry chain to empirically test the impact of digital technology on the development intensity of the industry chain. First, we determine the specific industries of the industrial chain, such as the manufacturing industry chain, including the food manufacturing and tobacco industry chain, the textile and apparel industry chain, the metal product industry chain, and the energy industry chain. Then we select variables and construct models to consider the heterogeneity of inter-industry chain to construction model.

$$ICS_{it} = \beta_0 + \beta_1 DPI_{it} + \beta_2 DSI_{it} + \beta_3 DPI_{it} * ICS_{it} + \beta_4 DIS_{it} * ICS_{it} + D + \beta_5 D * DPI_{it} + \beta_6 D * DSI_{it} + \varepsilon_{it} \quad (1)$$

Where ICS_{it} , DPI_{it} , and DSI_{it} represent development intensity of the manufacturing industry chain i in year t , digital hardware facility investment and digital software facility investment i in year t , respectively. Data used to compute DPI_{it} comes from the statistical data on computers, communications and other electronic equipment in China's input-output table from 1990 to 2018 and data used to compute DSI_{it} and ICS_{it} comes from the 1990-2018 China input-output table, the extension of input-output table and data on corresponding statistical items such as telecommunications, radio and television and satellite transmission services, Internet and related services, and software and information technology services in the extended input-output table. As for control variables, scholars generally choose some factors that may affect the explained variables as control variables according to the purpose of the research and the availability of data, and there is no certain standard in the selection of control variables (Frank, 2005; Gan et.al, 2011; Wang et.al, 2020). In order to avoid the disadvantages of the conventional control variable selection method, this paper introduces the cross-multiplication term of the core explanatory variable and the explained variable as the control variable into the model. The development of the digital economy has gone through two stages which are consumer Internet and industrial Internet, and the industrial Internet, which started in 2012, has a more important and far-reaching impact on the manufacturing industry chain [23]. In order to examine whether there are differences in the impact of the digital economy on the strength of the industrial chain before and after the application of the Industrial Internet, the time dummy variable D is introduced in formula (1), and before 2012 is assigned a value of 0, while after 2012 is assigned to be 1. The interactive terms respectively represent the effects affecting the strength of the industrial chain through time.

5. Empirical Results

Based on theoretical analysis, this paper puts forward two hypotheses about the relationship between the digital economy and the strength of the industrial chain. This section further performs empirical testing.

Table 2 shows the descriptive statistics of the main variables at the manufacturing industry chain level from 1990 to 2018.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std.Dev	Min	Max
ICS	221	.2365504	.0444033	.1372698	.4174289
DPI	221	.1473141	.2503798	.0094822	1.153
DSI	221	.0222467	.0125601	.0065304	.1327225

We can see from formula (1) that the explanatory variable appears on the right side of the empirical model. Therefore, the model itself contains an endogenous problem. In order to alleviate the impact of the endogenous problem on the results, this paper adds the panel generalized moment estimation (GMM) method for regression analysis based on baseline model OLS, and adopts the robust standard error method to correct the influence of heteroscedasticity. Table 3 reports the results.

Table 3. Regression Results

	(1) OLS	(2) FE	(3) RE	(4) GMM
DPI	0.0239 (1.06)	0.0239 (1.13)	0.0239 (1.10)	-0.00364 (-0.18)
DSI	-9.152*** (-16.63)	-9.152*** (-12.28)	-9.152*** (-11.93)	-9.068*** (-32.56)
DPI*ICS	-0.0921 (-1.02)	-0.0921 (-1.17)	-0.0921 (-1.13)	0.0381 (0.44)
DSI*ICS	44.64*** (20.86)	44.64*** (13.02)	44.64*** (12.65)	42.99*** (32.27)
D	0.0114 (1.39)	0 (.)	0.0114 (1.10)	0.000515 (0.09)
D*DPI	-0.00451 (-0.53)	-0.00451 (-0.59)	-0.00451 (-0.57)	-0.00378 (-0.40)
D*DSI	-0.925** (-2.49)	-0.925** (-2.20)	-0.925** (-2.14)	-0.331 (-1.41)
_cons	0.217*** (45.89)	0.214*** (48.59)	0.217*** (31.49)	0.216*** (76.66)
N	221	221	221	208

Notes: t statistics in parentheses * p<0.1, ** p<0.05, *** p<0.01

The baseline model in Table 3 column 1 states that DSI poses negative effect to the intensity of ICS, which suggests that the more investment in software produces less output. This baseline result is verified by fixed effect, random effect and GMM estimation, which verifies the H2. The basic result also indicates that DPI virtually has no impact on ICS, which is a surprise. As discussed above, we have reason to consider potential differences before and after 2012, while the results show no difference at all. However, lag of effect may also be another reason explaining that no difference shown in empirical results. In this regard, we set dummy variable to 2015, but the empirical results are still the same shown in Table 4.

Table 4. Reset Dummy Regressions

	(1) OLS	(2) FE	(3) RE	(4) GMM
DPI	0.0171 (0.86)	0.0171 (0.94)	0.0171 (0.91)	-0.00829 (-0.44)
DSI	-9.064***	-9.064***	-9.064***	-9.187***

	(-15.70)	(-11.92)	(-11.58)	(-33.86)
DPI*ICS	-0.0686 (-0.85)	-0.0686 (-0.99)	-0.0686 (-0.96)	0.0593 (0.70)
DSI*ICS	44.02*** (19.91)	44.02*** (13.04)	44.02*** (12.67)	43.75*** (34.61)
D	0.0222** (2.49)	0 (.)	0.0222*** (3.27)	0.0264*** (2.84)
D*DPI	-0.00461 (-0.67)	-0.00461 (-0.66)	-0.00461 (-0.64)	-0.00164 (-0.14)
D*DSI	-1.423*** (-3.55)	-1.423*** (-5.43)	-1.423*** (-5.28)	-1.237*** (-3.11)
_cons	0.218*** (47.69)	0.215*** (51.63)	0.218*** (34.14)	0.213*** (88.87)
N	221	221	221	208

Notes: t statistics in parentheses * p<0.1, ** p<0.05, *** p<0.01

According to the above model (1), partial derivatives of DPI_{it} and DSI_{it} can be obtained to obtain the effects of and on the strength of industrial chain, as shown in Equations (2) and (3).

$$\frac{\partial ICS_{it}}{\partial DPI_{it}} = \beta_1 + \beta_3 ICS_{it} + \beta_5 D \tag{2}$$

$$\frac{\partial ICS_{it}}{\partial DSI_{it}} = \beta_2 + \beta_4 ICS_{it} + \beta_6 D \tag{3}$$

According to the test results in Table 3, formula (2) and Formula (3) are combined. The specific effects of DPI_{it} and DSI_{it} are calculated, as shown in Table 5. Where, \bar{ICS} represents the mean value of industrial chain strength, which can be obtained by calculating the mean value of industrial chain strength from 1990 to 2018.

Table 5. The effect of digital hardware facilities and digital software services on the strength of industrial chain

Variable	Influential effect
\bar{ICS}	0.2365504
Bias effect of DPI ($\hat{\beta}_1 + \hat{\beta}_3 \bar{ICS} + \hat{\beta}_5 D$)	-0.140743
Bias effect of DSI ($\hat{\beta}_2 + \hat{\beta}_4 \bar{ICS} + \hat{\beta}_6 D$)	0.4393017
Total effect	0.2985587

As can be seen from the calculation results in Table 5, in general, the total effect of digital economy on the strength of manufacturing industry chain is positive, indicating that digital economy does promote the development strength of manufacturing industry chain, which also verifies hypothesis H1. In addition, the partial effect of DPI_{it} on the strength of manufacturing industry chain is negative, indicating that China's investment in digital hardware facilities

cannot meet the needs of current development, and it is urgent to further increase quantity and improve quality to meet the needs of manufacturing industry. The partial effect of DSI_{it} on the strength of the manufacturing industry chain is positive, indicating that digital software service has a certain promoting effect on the development of the manufacturing industry chain. Digital software service is the continuous power source for the strength of the manufacturing industry chain, and is the top priority for the strength of China's industrial chain.

6. Concluding Remarks

In recent years, with the outbreak of a series of "black swan" events, the digital economy and the strength of the industrial chain have become an important issue in the economic security of the country's industrial security. In this regard, this article analyzes the impact of the digital economy on the industrial chain from the perspective of the four internal chains included in the industrial chain, and empirically examines the impact of digital hardware facilities and digital software services on the strength of the industrial chain. The empirical results have three implications.

(1) The digital economy can effectively increase the strength of the industrial chain, especially since 2012, with the in-depth integration of digital technology and the real economy, the role of the digital economy in improving the strength of the industrial chain has been significantly enhanced.

(2) The growth of investment in digital hardware facilities has been relatively slow, which lags far behind the growth of investment in digital software services, and has been unable to meet the actual needs of the current rapid economic development. As a result, digital hardware facilities have become a constraint to the increase in the strength of the industrial chain.

(3) The input of digital software services has a negative effect on the development of the manufacturing industry chain, indicating that the current input-output curve of digital software services may be in the downward phase of the inverted "U" curve, and there is an urgent need for transformation for high-quality development. However, the partial effect of software services on the strength of the manufacturing industry chain is positive, and the promotion of the strength of the industry chain is clear, is the key of the digital economy to increase industrial strength.

While enriching existing researches, this article also offers two important enlightenments. Accordingly, this article puts forward the following policy recommendations.

(1) It is necessary to promote the high-end development of digital hardware facilities and form a dynamic balance of supply and demand for new infrastructure in the industrial chain. Digital hardware facilities are the foundation of the digital economy. At present, China's digital hardware facilities lag behind the needs of rapid economic development, and an urgent request needed to upgrade to high-end development. First of all, the government must abandon simple subsidy policies and replace them with more effective policy support systems and service systems such as industry guidance, financial support, and high-end talent cultivation. Secondly, technological breakthroughs in "nuclear high-based" products such as chips, integrated circuits, and basic raw materials through industrial alliance innovation and collaborative innovation across the entire industry chain are opportunities for the government to seize the urgent need for upgrading and transformation of current digital infrastructure.

(2) It is also beneficial for the government to promote the high-quality development of digital software services and unblock the industry chain cycle to ensure safety and independence. Digital software services are the technical support to ensure the cross-temporal flow of information in the industry chain, and the role of industrial software is crucial. Industrial software is the core part of digital software services, but it is another shortcoming that China is restrained by others, which greatly threatens the safety and stability of industrial chain in China.

The development of safe, autonomous and controllable industrial software can seek breakthroughs from the following three aspects. First, the idea of long-term success should be established. The development of Industrial software must be based on rigorous industrial logic and deep industrial accumulation, rather than short-sightedness and speculation. Second, compared with the traditional monopoly advantages of developed countries in the field of single-disciplinary key design and development tools, multi-field software automatic generation technology based on unified model specifications is the direction of industrial software innovation and the breakthrough point for China to form late-comer advantages. industrial knowledge and manufacturing experience are the foundation of industrial software. Last, while vigorously developing advanced manufacturing, it is necessary to deeply and persistently promote the in-depth integration of industrial knowledge research and industrial applications, and gradually form independent and controllable industrial software design and R&D knowledge.

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