

# A review of research on global value chain upgrading of manufacturing enabled by digital economy

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**Abstract:** *The digital economy based on a new generation of digital technology has become a new driving force for the transformation and upgrading of the manufacturing industry, but the existing research is relatively lagging behind and difficult to effectively guide China to get rid of the low-end lock in the manufacturing industry. This paper focuses on how the digital economy upgrades the global value chains of manufacturing industry at the enterprise and industrial levels, and reviews the upgrading of the value chain of manufacturing industry enabled by the digital economy from four aspects: digital infrastructure, digital technology, manufacturing digitization and digital service industry. It is found that there are many research perspectives, methods and fruitful results on this topic. However, it has not formed a systematic theoretical system. It is hoped that more studies in the future can focus on the measurement of digital economy and value chain upgrading, so as to have more accurate and unified indicators to measure the empowerment of digital economy to manufacturing value chains, and include more new categories in digital economy into the analytical framework.*

**Keywords:** *digital economy; upgrading of global value chains; low-end locking*

## 1. Introduction

For a long time, relying on the comparative advantage of abundant labor resources, China has participated in the global value chain mainly through the development of processing and production industries, and gradually played an increasingly important role in the international division of labor system. However, compared with some developed countries', China's manufacturing industry is limited by the lack of core technology and faces the risk of low-end locking<sup>[1]</sup>. Therefore, how to get over the difficulty of the key technology of China's manufacturing industry "stuck neck" and get rid of the dilemma of "low-end lock", so as to realize the jump in the global value chain is the current problem that China must seriously face and try to solve. Typical cases such as the intelligent manufacturing model of Haier COSMOPlat and the rise of digital platforms such as Meituan and Didi all show the power of the digital economy, and the digital economy has become a trend to upgrade the manufacturing value chain by driving China's manufacturing industry to move to the bottom and top of the global value chain. The development of digital economy has reshaped the manufacturing industry. "Unmanned factory" not only means the improvement of production efficiency, but also promotes the upgrading of human capital. While actively integrating into the global innovation network in the digital transformation, it also provides an empirical basis for solving the lack of core technology; In addition, digital technology can also be used to understand and respond to market needs in a timely manner, which greatly improves the efficiency of resource allocation in the manufacturing industry. Therefore, enabling the development of manufacturing industry through digital economy is an effective way to improve the position of China's value chain.

The digital economy driving the upgrading of China's manufacturing industry has attracted extensive attention from scholars, and also led to the rapid evolution of theoretical research. According to the G20 Digital Economy Development and Cooperation Initiative released by China in 2016, "Digital economy refers to the sum of economic activities that use digital information and knowledge as production factors, information networks as carriers, and the use of ICT to promote efficiency improvement and macroeconomic structure optimization." However, no consensus has been reached on the connotation of global value chain upgrading. Generally, the narrow sense of global value chain upgrading refers to the transfer or extension of production links in the value chain<sup>[2]</sup>, and the broader connotation is as follows: Value chain upgrading is a continuous and dynamic process, which is manifested in the breadth and depth of GVC, that is, the geographical space and market scope involved

in a country's participation in GVC activities and the country's voice and status in the value chain it participates in<sup>[3]</sup>. In addition to discussing the connotation and measurement of global value chain upgrading, many studies have also explored the path of manufacturing value chain upgrading from multiple perspectives, such as outbound investment<sup>[4]</sup>, manufacturing servitization<sup>[5]</sup>, intermediate goods import<sup>[6]</sup>, and technological innovation<sup>[7]</sup>. Although there have been many effective studies on the upgrading path of global value chain, the effectiveness received is relatively limited, and it can not effectively guide China's manufacturing industry to get rid of the dilemma of low-end lock; The digital economy can empower the manufacturing industry through the improvement of production efficiency, technological innovation and product quality<sup>[8-10]</sup>, and can empower the value chain upgrading of the manufacturing industry through digitalization and servitization, which provides an opportunity for the upgrading of the global value chain of the manufacturing industry<sup>[11, 12]</sup>.

In the existing literature, the research of digital economy on the manufacturing industry has been carried out from multiple perspectives, such as the improvement of quality and efficiency at the enterprise level, the digital transformation and upgrading of the industry, and the integration and agglomeration of the industry, and has adopted various methods such as quantitative and qualitative analysis, and has achieved fruitful results. However, these studies have not been systematic and systematic. Therefore, this paper systematically reviews how digital economy enables the upgrading of manufacturing value chain, the specific mechanism and path, as well as the existing research gaps and research prospects.

## **2. Digital economy enables the basic logic of upgrading the global value chain of manufacturing industry**

In the era of digital economy, whether and how to use digital economy to change the status quo of low-end locking in China's manufacturing industry to achieve the upgrading of manufacturing value chain has become a hot issue. In this regard, many scholars have discussed the basic logic of digital economy enabling the upgrading of the global value chain of manufacturing industry from multiple perspectives. After sorting it out, this paper finds that this upgrading logic is mainly reflected in the micro enterprise level and the middle industry level.

### ***2.1. The digital economy drives the upgrading of China's manufacturing value chain by improving quality and efficiency at the enterprise level***

First, the digital economy can enable the upgrading of the manufacturing value chain through enterprise technological innovation. In 2020, Wen Jun et al. found through empirical research that digital economy can promote the improvement of innovation ability<sup>[13]</sup>. On this basis, Hu Shan and Yu Yongze (2022) found that the digital economy can promote the breakthrough innovation of enterprises by easing the financing constraints of enterprises, promoting industry-university-research cooperation and improving the rate of return on patents [8]. More in-depth studies are: Li Jian et al. (2022) Digital economy affects the internal resources of enterprises by alleviating financing constraints and optimizing the structure of human capital, reduces the concentration of supply chain and expands the knowledge network of enterprises to affect the external resources of enterprises, thus driving the improvement of enterprises' innovation ability<sup>[14]</sup>. However, Wang Wenpu and Xu Aiting (2022) found that the effect of human resource agglomeration, the effect of financing constraint mitigation and the effect of business environment optimization play a significant role in the improvement of innovation efficiency of digital economy<sup>[15]</sup>. To sum up, digital economy can promote technological innovation of enterprises, and technological innovation can drive high-tech industries to upgrade the global value chain<sup>[16]</sup> and play an important driving role in the high-end value chain<sup>[7]</sup>.

Second, the digital economy can upgrade the manufacturing value chain through the improvement of product quality. Ma Zhongdong and Ning Zhaoshan (2022) found through empirical research that the digital economy can enable the upgrading of product quality by optimizing the allocation of labor and capital resources<sup>[17]</sup>, and Lin Feng and Qin Jiahui (2022) further found that technological innovation is also a path for the upgrading of product quality in the manufacturing industry enabled by the digital economy<sup>[9]</sup>. On this basis, Li Yabo and Cui Jie (2022) found that the digital economy has a more obvious effect on the quality improvement of products with greater quality differences, and believed that this effect will be weakened with the increase of the degree of embedded GVC<sup>[18]</sup>. At present, there are relatively few researches on this topic, and they pay more attention to empirical research, and few sublimation to theoretical research. Digital economy can enable enterprises to

improve the quality of export products, while it is generally believed that developed countries have higher standards for product quality, and enterprises are more conducive to participating in the global value chain by producing high-quality export products. Hu Zhaoling et al. (2019) confirmed this view through empirical research. In other words, the improvement of product quality has a significant positive effect on the participation of global value chain<sup>[19]</sup>.

Third, the digital economy can enable the upgrading of the manufacturing value chain through the improvement of production efficiency. Wang Kaike et al. (2020) concluded through theoretical analysis that the enhancement of the versatility of digital technology has enabled the development of digital economy to improve production efficiency<sup>[20]</sup>, and many literatures have also drawn specific paths for digital economy to promote total factor productivity. Digital economy can enable the improvement of total factor productivity through the optimal allocation of data factors<sup>[10]</sup> and the upgrading of industrial structure<sup>[21]</sup>. Technological efficiency and technological progress effect are also important influence paths, and most existing literatures believe that the path of enhancing technological efficiency enabled by digital economy is more significant<sup>[22,23]</sup>. In other words, digital economy can promote the improvement of production efficiency, and the difference of labor productivity is one of the most important factors determining the international division of production<sup>[24,25]</sup>. Therefore, the digital economy can promote the promotion of the international division of labor by improving production efficiency, thus enabling the upgrading of the manufacturing value chain. The existing literature on this topic research perspective is rich, the research is also more in-depth.

The above three action paths mainly focus on the intra-enterprise level, but the existing literature rarely studies how to empower the digital economy to drive the improvement of the value chain from the perspective of inter-enterprise.

## ***2.2. The digital economy drives the upgrading of China's manufacturing value chain through industrial digitalization and structural upgrading***

First, the digital economy can enable the upgrading of the manufacturing value chain through manufacturing services. For example: The rise of big data can also drive the service-oriented transformation of the manufacturing industry by alleviating and overcoming the "service paradox" [11], and the development of digital finance can also promote the service-oriented manufacturing industry, because digital finance stimulates entrepreneurs' willingness to implement service-oriented strategies, although this effect is in line with the law of diminishing marginal utility. However, there is an obvious superposition effect on a longer timeline<sup>[26]</sup>. The above literature shows that the development of digital economy can promote the servitization of manufacturing industry. In addition, many literatures believe that the servitization of manufacturing industry can promote the upgrading of the value chain. Luo Jun (2018) found through empirical research that servitization can promote the upgrading of value chain status through resource allocation effect and cost saving effect, and pointed out that servitization of manufacturing industry is a feasible path to realize the climbing of value chain<sup>[27]</sup>. On this basis, Dai Xiang (2020) used the proportion of domestic and foreign service input to represent the servitization of manufacturing industry, and found that servitization represented by the proportion of domestic service input had a significant positive effect on the GVC division of labor of manufacturing industry, while that represented by the proportion of foreign service input had a significant negative effect<sup>[12]</sup>. Further, Qi Liangqun et al. (2022) found that the servitization of the manufacturing industry can drive the upgrading of the global value chain by improving the exploration and application capabilities of enterprises<sup>[28]</sup>. There are many researches in this part, and the perspective is also rich.

Second, the digital economy can enable manufacturing value chain upgrading through industrial transformation and upgrading. Zhao Xisan (2017) concluded through qualitative analysis that the development of digital economy could solve some problems faced by the transformation and upgrading of China's manufacturing industry and thus help the transformation and upgrading of the manufacturing industry<sup>[29]</sup>, while Jiao Yong (2020) believed that the digital economy could enable the transformation of the manufacturing industry through value reshaping in the short term and value creation in the long term<sup>[30]</sup>. Some literature also believes that the digital economy can enable the digital transformation of China's manufacturing industry through deep integration with the real economy<sup>[31]</sup>, so as to realize the value chain upgrade. Most of the above literature qualitatively analyzes the impact of digital economy on the upgrading of manufacturing industry, and there are also many empirical studies that confirm the above views. Shen Yunhong (2020) found through empirical research that digital infrastructure, digital industry and digital technology innovation can all enable the structural optimization of China's traditional manufacturing industry, but digital technology innovation has a small time lag<sup>[32]</sup>. On this basis, many literatures have also studied the specific impact mechanism, and most of them believe that

digital economy can enable the transformation and upgrading of manufacturing industry through human capital accumulation and technological innovation<sup>[33,34]</sup>. Digital economy can drive the upgrading of industrial structure, and the upgrading of industrial structure will promote the flow of production factors to high-growth and high-efficiency industries, that is, improve the efficiency of resource allocation and accelerate technological change, thus enhancing the status of global value chain [35]. The existing researches have a relatively narrow perspective on the digital economy's effect on the upgrading of manufacturing industry, and the researches on the role path of enabling manufacturing industry to upgrade the manufacturing value chain are still relatively shallow.

Third, the digital economy can enable the upgrading of the manufacturing value chain by promoting industrial integration. The digital economy can also enable the upgrading of the manufacturing value chain from the inter-industry level through deep integration with the real economy, industrial agglomeration and improving the resilience of the industrial chain. Through empirical analysis, Liu Yinghengtai and Yang Lina et al. (2022) found that the integration of digital economy and manufacturing industry is relatively low<sup>[36]</sup>, but many literatures pointed out that the integration of digital economy and manufacturing industry can improve innovation efficiency<sup>[37]</sup> and enhance international competitiveness<sup>[38]</sup>. On this basis, many literatures also put forward the specific logic and path for the deep integration of digital economy and manufacturing industry. For example, Wang Jiayuan (2022) analyzed the empowerment of digital economy for the deep integration of industries from three dimensions: data value, data technology and network carrier; In 2023, Hong Yinxing and Ren Baoping analyzed the integration path of digital economy and real economy from three aspects: enterprise innovation, industrial innovation and enterprise organizational innovation<sup>[39]</sup>. To sum up, digital economy can promote industrial integration, and industrial integration can promote the rise of GVC value potential in manufacturing industry by amplifying the rising effect of industrial resource input factors on GVC value potential<sup>[40]</sup>. The integration of digital economy and manufacturing industry is a hot research issue, but the research perspective is relatively limited, and few literatures analyze its impact on the manufacturing value chain.

In addition, there are also some literatures from other perspectives on the empowerment of the digital economy on the inter-industry level of manufacturing. For example, Qiao Bin and Dai Pei Xin (2023) found that digital economy promotes industrial coaggregation through specialized division of labor<sup>[41]</sup>, while Shao Chaopair and Su Danyi (2019) found that industrial agglomeration achieves the growth of export DVAR through the structural effect of promoting the transformation of processing trade mode of low-export DVAR to general trade mode of high-export DVAR<sup>[42]</sup>. In addition to promoting industrial agglomeration, the digital economy can also improve the resilience of the value chain<sup>[43]</sup> and drive the deep integration of urban and rural industrial chains<sup>[44]</sup>. In general, the researches in this part are relatively shallow and the perspective is relatively limited, and there are few literatures that have studied this part deeply into the impact on the manufacturing value chain.

In general, the existing studies on the impact of digital economy on the manufacturing value chain are mainly carried out from the enterprise level and the industry level. Few literatures analyze this enabling effect from the perspective of enterprises, and the literature analyzing this effect from the inter-industry level is gradually increasing.

### **3. The digital economy enables the main path of upgrading the global value chain of manufacturing Study design and empirical testing**

#### ***3.1. Enabling manufacturing to upgrade the global value chain through digital infrastructure***

Digital infrastructure is widely used in e-commerce, financial services and other fields. It can penetrate into all links of the manufacturing industry chain, and has a great impact on the value chain of China's manufacturing industry. In the existing literature, the impact of digital infrastructure on the upgrading of the global value chain of the manufacturing industry is relatively small, mainly from a micro perspective, and there are many empirical studies, among which the impact of digital infrastructure on the position of the global value chain is relatively small, and most of the studies in this part choose the domestic value added rate of exports or the technological complexity of exports as explained variables, and there are few theoretical analyses. There are few literatures on qualitative analysis of this topic, and the overall research is shallow. In general, digital infrastructure can not only reduce the production cost of enterprises and improve the production efficiency of enterprises, but also promote the increase of the added value of products and achieve value appreciation, thus promoting the upgrading of the global value chain.

Many literatures have concluded through quantitative analysis that digital infrastructure can enhance the position of division of labor in the value chain or promote China's participation in the global value chain. For example, in 2020, Li Jin et al. found through empirical tests that digital infrastructure can enhance the position of the value chain by improving knowledge spillover efficiency and stimulating innovation. It is also believed that digital infrastructure has a consistent impact on a country's participation in the value chain<sup>[45]</sup>. On this basis, Feng Zhengqiang and Yu Jiahui found through empirical analysis in 2021 that new infrastructure would not only promote the improvement of export technology level, but also promote the transformation of export product structure by inhibiting the export of labor-intensive products<sup>[46]</sup>. It can be seen that technological innovation is one of the main ways for digital infrastructure to empower the manufacturing value chain, as follows: the essence of a country's value chain upgrading is that a country pays more attention to innovation<sup>[45]</sup>. Although few literatures directly study the impact of digital infrastructure on technological innovation, many literatures believe that technological innovation is an important path for the digital economy to empower the manufacturing value chain.

At the same time, many literatures analyze that digital infrastructure enables manufacturing to be service-oriented to drive the upgrading of the value chain. In 2019, Wang Yicchen found through qualitative analysis that the industrial Internet can enable manufacturing to be service-oriented by solving some problems in the process of manufacturing being service-oriented,<sup>[47]</sup> while Liu Bin et al. (2016) found through quantitative analysis of the data of micro-enterprises that: Manufacturing servitization can improve the quality of enterprises' export products through horizontal and vertical effects<sup>[48]</sup>. In summary, industrial Internet can improve the quality of enterprises' export products by driving manufacturing servitization, thus enabling the upgrading of the manufacturing value chain. Further, in 2021, CAI Chengwei and Qi Yudong conducted a qualitative analysis on the industrial Internet enabling manufacturing industry, and found that the industrial Internet can use the accumulated data to empower enterprises, products and value chains to improve innovation ability and risk resistance, and enhance added value through product service, so as to improve the overall competitiveness of China's manufacturing industry<sup>[49]</sup>. It can be seen that product service is another important path for digital infrastructure to empower China's manufacturing industry, which is mentioned in many literatures.

### ***3.2. Enabling manufacturing to upgrade the global value chain through digital technologies***

Relying on "digital empowerment" to promote the development of digital, intelligent, green and service-oriented industries is the only way for China to achieve the climb of the global value chain. Many literatures believe that digital technology can empower China's manufacturing industry by reducing costs and improving innovation efficiency, and promote the climb of global value chain and the transformation and upgrading of manufacturing industry. For example: Through empirical analysis, Gao Jingfeng and Wang Bin (2020) conclude that digital technology can significantly improve China's position in the global value chain, but the use of foreign digital technology can better promote the improvement of China's position in the complex value chain, and believe that the reason for this difference is the difference in the division of labor of different links in the value chain. It is also believed that digital technology enhances the position of global value chain through technology substitution effect and synergistic penetration effect<sup>[50]</sup>, but no mechanism test has been conducted on these two effects. Further, some literatures verify the specific path of digital economy enabling manufacturing industry. For example, Liu Bin and Pan Tong (2020) conclude through empirical tests that artificial intelligence improves the participation and division of labor of China's manufacturing industry by reducing trade costs, promoting technological innovation and optimizing resource allocation, and find that artificial intelligence promotes the first-mover advantage of GVC competition. In view of this topic, Zheng Qiongjie and Wang Gaofeng (2021) believe that artificial intelligence, as an advanced factor of production, changes the structure of production factors of enterprises, thus promoting technological innovation and productivity improvement of enterprises, and realizing the climb to the high value-added links at both ends of the value chain<sup>[51]</sup>. In 2022, the driving effect of artificial intelligence on the rise of GVC in the manufacturing industry was confirmed by empirical evidence, but this driving effect was more obvious for high-tech industries<sup>[52]</sup>. Different from the specific mechanism mentioned in the above two viewpoints, Liu Shuguang and Meng Qingjie (2022) found through empirical analysis that artificial intelligence drives the promotion of global value chain status through two paths of human capital level and new product research and development, and found that this effect is more significant for resource - and labor-intensive industries<sup>[53]</sup>. It may be because of the difference in index selection or data processing that this result is different from the industry heterogeneity test results mentioned above. It can be seen from the above literature that innovation is

an important role path for digital technology to drive the rise of GVC in manufacturing industry. There are also many literatures that further study the specific path for digital economy to enable innovation. For example, big data can promote product design innovation by mining customer needs<sup>[11]</sup>. Cong Hao and Zhang Chunyu (2022) found that digital technology can promote high-quality innovation in enterprises through two ways: increasing the quantity of innovation output and improving human capital<sup>[54]</sup>. Different from these two views, Du Chuazhong and Jiang Ying (2022) found through empirical analysis that digital technology can improve the innovation efficiency of enterprises through three ways: talent structure, financing structure and industry-university-research cooperation intensity<sup>[55]</sup>. In addition, other influence paths have been mentioned in some literatures. For example, the application of artificial intelligence can also enable the upgrading of the manufacturing value chain by improving the total factor productivity of enterprises, reducing export costs and increasing the types of domestic intermediate goods<sup>[56, 57]</sup>. In 2023, Lu Yue et al. gave a more comprehensive answer through empirical research: artificial intelligence can not only promote the deepening of GVC network in various countries, but also extend the length of GVC, and promote countries to climb upstream of GVC<sup>[58]</sup>. This part of the research literature is more, the perspective is also relatively rich, mainly quantitative analysis.

In recent years, many literatures have studied the impact of digital technology on the manufacturing industry, mainly focusing on the impact of artificial intelligence and big data on the global value chain of the manufacturing industry, but the overall research is shallow. For example, many literatures have empirically verified the role path of digital technology enabling the manufacturing industry. However, few literatures combined with the specific characteristics of China to analyze whether these mechanisms of action under different conditions will have different results. Secondly, the perspective of the research is relatively narrow, focusing on the industry, product and value chain level.

### ***3.3. Enabling the upgrading of the global value chain of the manufacturing industry through the digitalization of the manufacturing industry***

With multiple factors such as the COVID-19 epidemic, labor costs and inflation superimposed, digital transformation of China's manufacturing enterprises is the only way to break through the current predicament. In the era of digital economy, a country's domestic industrial transformation and upgrading path is the only way for China to achieve the climb of global value chain,<sup>[59]</sup> relying on "digital empowerment" to promote industrial digital transformation is an important path to achieve the climb of global value chain. Most of the literatures on the impact of industrial digital transformation on the manufacturing value chain focus on the digitalization of manufacturing industry and its impact on the global value chain, and few literatures take the digitalization of service industry as the research object.

Many literatures believe that the digital transformation of manufacturing industry can drive the rise of the global value chain of China's manufacturing industry. For example, Dang Lin et al. (2021) found through empirical research that the digital transformation of manufacturing industry has a nonlinear enhancement effect on the technical complexity of export<sup>[60]</sup>. On this basis, Li Songqing and Hu Zhiju (2022) concluded through empirical analysis that: The digitalization of manufacturing industry drives the promotion of GVC status through two paths of industrial transformation and upgrading and productivity, but this effect is not significant for technology-intensive industries. It is believed that this is due to the lack of core technology, but Wu Youqun et al. (2022) conducted a heterogeneous test and concluded that digital investment has a more significant promoting effect on the improvement of GVC competitiveness in low - and medium-high knowledge-intensive industries, and that this is because these two industries are easier to realize digital transformation and thus improve collaborative efficiency and production cost<sup>[61]</sup>. The existing literature mainly divides industries according to the degree of technology intensity and conducts heterogeneity test. The difference in test results may be due to the different basis of industry division or the different selection of explained variables.

At the same time, many literatures have also studied the specific mechanism of enabling manufacturing industry by digital transformation. CAI Chengwei and Qi Yudong (2021) Digital transformation can improve innovation ability and risk resistance by promoting digitalization of production process, platform of industrial chain and product service, so as to improve the competitiveness of manufacturing industry<sup>[49]</sup>. There are also many literatures that believe that cost saving, resource allocation optimization and synergy effect<sup>[61-63]</sup> are the main paths for manufacturing value chain upgrading enabled by digital transformation. On this basis, Sun Xinbo et al. (2023) drew a more comprehensive conclusion: data can realize the progressive climb of the value chain of intelligent manufacturing enterprises through the empowerment of employees, management and processes, and

the breakthrough climb of the value chain through the empowerment of customers and cooperation<sup>[64]</sup>.

There are many quantitative analyses based on different measurement indicators, and many literatures systematically analyze the empowerment of manufacturing digitalization to manufacturing value chain.

### ***3.4. Enabling the upgrading of the global value chain of manufacturing through digital services***

Digital economy can also enable the upgrading of China's manufacturing value chain through service industry or manufacturing service-oriented, and there are many literatures on this as the research object. Digital economy can promote the service of enterprises by increasing the intensity of innovation and the level of digitalization<sup>[26]</sup>. In 2016, Liu Bin found through empirical analysis that the service of manufacturing industry can not only improve the participation of GVC in China, but also improve the division of labor in the value chain, and improve the quality of enterprises' export products<sup>[48]</sup>. This confirms that the digital economy can promote the upgrading of the value chain by enabling the manufacturing industry to serve. The research on the upgrading of the enabling value chain of digital services mainly focuses on digital finance and digital trade. Digital trade will embed digital products and services in global value chains, making value creation increasingly knowledge-intensive<sup>[65]</sup>. Moreover, the development of digital finance has improved the financing efficiency of smes and contributed to the digital transformation of smes. Therefore, this part from the digital trade and digital finance two aspects to study the digital service industry to enable manufacturing GVC upgrade.

The existing literature mainly studies the empowerment of digital service industry to manufacturing industry from the perspective of export products and the upgrading of industrial structure. For example, Han Minchun and Zhang Xiao (2023) found that digital trade promotes the upgrading of export products through the reduction of trade costs, technological innovation and the improvement of financial service efficiency; Existing studies on the upgrading of industrial structure suggest that digital trade can drive the upgrading of industrial structure through the transformation of digital resource endowment comparative advantage<sup>[66]</sup>, human capital and R&D intensity<sup>[67]</sup>. These literatures have all confirmed the driving role of digital economy in upgrading the manufacturing value chain. Further, Yang Huiying et al. (2022), through empirical research on countries within the RCEP framework, found that: The development level of a digital trade has a "U-shaped" relationship with a country's position in the global value chain, which is believed to be due to the large fixed costs in the early stage of digital trade development<sup>[66]</sup>. However, since the sample selected in this paper is different from other literatures mentioned above, this conclusion may not be consistent with the specific national conditions of our country.

The existing literature on the impact of digital finance on the manufacturing industry is mainly analyzed from the perspective of enterprises. Sun Zheyuan (2022) found through empirical research that the development of digital finance promoted the climb of global value chain by improving the development level of small and medium-sized enterprises<sup>[68]</sup>. Some literatures have also found that digital finance can affect the servitization of manufacturing industry by improving the innovation intensity of enterprises<sup>[26]</sup>, while servitization of manufacturing industry can improve the quality of export products by improving product quality and product technical complexity<sup>[48]</sup>. The above literature shows that the development of small and medium-sized enterprises is one of the important ways that digital finance enables the upgrading of the manufacturing value chain. There are also studies that analyze the impact of digital finance on the manufacturing industry from the industry level. Xu Zhao (2022) finds that digital finance can improve the scale, efficiency and position in the value chain of the manufacturing industry through the effect of technological innovation and consumer demand<sup>[69]</sup>. Further, there are also literatures to prove the empowerment of digital finance on the manufacturing value chain from a more comprehensive perspective. In 2022, Chai Zhengmeng and Yang Yanfang found through quantitative analysis that the development of provincial fintech promoted the improvement of the manufacturing value chain, and this effect was sustained and increasing<sup>[70]</sup>.

With the development of digital economy, digital finance and digital inclusive finance have also become the focus of research, and many studies have analyzed the impact of digitalization of these industries on the manufacturing industry. However, in general, there are relatively few literatures on the impact of digital service industry on manufacturing industry, with narrow perspectives and shallow studies, mainly focusing on digital trade and digital finance.

#### **4. Proposed measures to upgrade the global value chain of manufacturing enabled by the digital economy**

##### ***4.1. Improving relevant policies to promote the development of the digital economy***

The introduction and improvement of relevant policies is the key to play the empowering role of the digital economy. For example, Guo Keshu and Yang Filong (2023) believe that the digital transformation of the manufacturing industry needs to strengthen the support and promotion role of the government, because the large amount of capital required for digital transformation and the complicated technologies involved make enterprises lack the motivation for digital transformation<sup>[71]</sup>. There is a lot of literature on the government's proposed measures to promote the development of the digital economy, mainly focusing on: the construction of new infrastructure, the development of the digital economy according to local conditions, and the optimization of the digital economy governance environment. The suggestions on digital infrastructure mainly include two aspects: one is hardware digital infrastructure, which mainly focuses on digital sharing platform, strengthening digital connectivity and supporting the development of digital technology; the other is software infrastructure, which focuses on education and business environment<sup>[45]</sup>. As for local policies, they mainly focus on developing appropriate digital technologies<sup>[56]</sup>, adopting differentiated and dynamic digital economic development strategies to reduce regional imbalances<sup>[72]</sup>, and appropriately increasing digital investment in low - and medium-technology manufacturing<sup>[73]</sup>. The suggestions on optimizing the governance environment of digital economy mainly focus on: improving digital standards and digital economy market system, property rights protection, regulations and supervision.

There are also many literatures that believe that in the context of digital economy reshaping the global value chain, China should actively participate in the governance of the global value chain. Relevant measures include: supporting the leading enterprises with strong local competitiveness to carry out innovation research and development, and building an industrial division of labor system with local enterprises as the "chain master" <sup>[74, 75]</sup>.

This part of the recommendations account for a large part of the recommendations in the current literature, and related policy recommendations mainly focus on: the construction of emerging infrastructure, the development of digital economy according to local conditions, the optimization of digital economy governance environment, and participation in global value chain governance.

##### ***4.2. Digital transformation of enterprises helps enterprises improve export competitiveness***

Under the tide of global digital revolution, digital transformation has become an important way for enterprises to improve their export competitiveness. Qi Yudong and Xiao Xu (2020) comprehensively summarized that Chinese enterprises should carry out digital transformation or intelligent upgrading from four aspects: establishing digital transformation awareness, formulating digital transformation strategies as soon as possible, cultivating and introducing digital talents, and making full use of relevant government policies.<sup>[76]</sup> There is also a lot of literature on more detailed proposed initiatives for enterprise digital transformation. In view of technical problems, Xu LAN and Wu Chaolin (2022) proposed that enterprises should change the previous model of product and process innovation together, and jointly carry out research on technological innovation<sup>[77]</sup>. Further, Lufen et al. (2022) provided specific digital innovation paths for different development goals of smes<sup>[78]</sup>. However, Lv Wenjing et al. (2019) pointed out that an enterprise should consider the governance model of GVC when making its own upgrade strategy, and choose its own transformation and upgrading path by using intelligent manufacturing. Leading enterprises can also transform to platform enterprises to realize the climb of the value chain<sup>[79]</sup>. On this basis, Geng Ye-Qiang and Bai Lifang (2019) pointed out that enterprises should pay attention to the internal training of talents and attract foreign talents, and believe that enterprises can actively participate in the process of GVC to absorb advanced technology to improve their level of technological innovation. There are relatively many literatures on how enterprises cope with the opportunities and risks in the era of digital economy, mainly focusing on technological innovation, talent training, digital transformation and so on.

##### ***4.3. Collaborative innovation to overcome technical difficulties to drive the upgrading of the value chain***

In view of the bottleneck of core technology in our country, collaborative innovation is an important way to improve innovation efficiency. First, industry-university-research cooperation should be



strengthened. In the era of digital economy, it is difficult for a single enterprise to apply the acquired knowledge to production by itself, while the collaborative work of the industry-university-research consortium can accelerate the transformation of knowledge into patents and production processes and promote technological progress<sup>[49]</sup>. Second, we should integrate innovation in opening up. Digital technology itself has the characteristics of openness. It accelerates its integration into the global value chain, strengthens international cooperation, integrates and utilizes global high-end resources, and achieves scientific and technological self-reliance in the open integration<sup>[80]</sup>. Third, enterprises jointly carry out research on digital technology innovation, comprehensively rely on various digital technologies to carry out digital transformation of enterprises, and continuously enhance the export competitiveness of manufacturing industry<sup>[77]</sup>. Faced with the weak situation of China's core technology, collaborative innovation is an important solution, which has been mentioned in many literatures, but the specific measures proposed in this part are relatively shallow.

## 5. Research review and prospect

To sum up, since the COVID-19 epidemic, the impact of digital economy on high-quality economic development, industrial transformation, and total factor productivity has been a research hotspot. The existing digital economy research literature on the upgrading of the manufacturing value chain provides a rich perspective and profound insight for us to explore the path of the upgrading of the manufacturing value chain in China. However, this paper believes that there are at least three shortcomings in the existing research:

First, the measurement of the development level of the digital economy and the measurement of GVC upgrade have not reached a consensus. Many literatures study the enabling effect of digital economy on manufacturing upgrading with digital economy as the core explanatory variable, but there is no consensus on the measurement of these two variables.

Second, how the digital economy enables the upgrading of the manufacturing value chain at the inter-firm level is rarely studied in literature. In the existing literature, studies on the empowerment of the digital economy on the manufacturing industry from the perspective of enterprises mostly focus on the economic effects of the digital economy on the internal enterprises, such as technological innovation, productivity improvement, etc., but few literatures analyze how to enable the upgrading of the manufacturing value chain through the interaction between enterprises.

Third, the academic community has not formed a systematic framework for the upgrading of the manufacturing value chain enabled by the digital economy. Most of the existing literature holds that digital economy enables manufacturing value chain upgrading by reducing cost, improving production efficiency and promoting innovation. However, with the development of the digital economy, many new technologies have emerged, such as how the application of digital twins enables manufacturing and other issues still need attention.

Based on the above research deficiencies, in addition to in-depth research on the path of upgrading the manufacturing value chain enabled by the digital economy from a richer perspective, future research should also pay attention to the following two issues:

First, it's very important to establish a reasonable and scientific accounting system to measure the development of digital economy and the upgrading of GVC correctly.

Second, we should study this topic from the level of enterprises and other aspects, so as to analyze the digital economy's impact on the manufacturing value chains from a richer perspective.

Third, it's a nice choice to expand the research framework and analyze the emerging technologies' impact on the global value chains, so as to upgrade the global value chains effectively.

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