

Research on the Coupling Mechanism between Industrial Digitalization and Digital Industrialization

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Abstract: The digital economy has emerged as a new engine driving China's economic growth. The support of the digital economy for regional high-quality development relies on the synergy, matching, and coupling between industrial digitalization and digital industrialization. Based on an in-depth review of the literature, this paper delves into the interaction mechanism between industrial digitalization and digital industrialization. Furthermore, it explores the formation mechanism and implementation path of coupling, and from the perspective of promoting regional high-quality development, proposes targeted countermeasures and suggestions to facilitate the coupling of the two.

Keywords: Industrial digitalization; Digital industrialization; Coupling; Mechanism of action

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1. Introduction

After the 1990s, the Internet, information technology, and real industry have been deeply integrated. With the rapid development of cloud computing, big data, and other technologies, the technological architecture is constantly improving from the infrastructure layer to the application layer. Scenario-based applications and emerging digital businesses are developing rapidly, and the era of “digital economy” has arrived. The Third Plenum of the 20th Central Committee of the Communist Party of China emphasized the importance of the digital economy and put forward the requirement to promote the deep integration of the real economy and the digital economy. The plenary session proposed that the digital economy, as a new form of economy, is highly compatible with the development of new quality productivity and can provide a continuous source of power for its growth. The plenary session requires accelerating the upgrading and practical implementation of digital technology, and promoting the deep integration of digital technology with traditional industries; Meanwhile, by driving industrial transformation and upgrading through digital technology, the automation, intelligence, and

efficiency of the production process can be achieved. This fusion process is essentially a process of integration, coordination, matching, and coupling between the supply of digital products (digital industrialization) and the demand for digital products (industrial applications). Therefore, studying the mechanism of the coupling between industrial digitalization and digital industrialization has certain value.

From existing literature, research on industrial digitalization, digital industrialization, and their relationship with high-quality economic development has been conducted and has achieved certain results. (1) Establish a quantitative (coupling degree measurement) analysis using Chinese data and propose countermeasures and suggestions. Li *et al.* used the second mock examination network model to analyze the two-way linkage between industrial digitalization and digital industrialization, and found that the synergy between ICT software and hardware industries was insufficient^[1]. Chen and Dai constructed a coupling coordination model to measure the coupling coordination between industrial digitalization and digital industrialization in Jiangsu Province from 2014 to 2018. Industrial digitalization also has a good driving effect on digital industrialization. Although the coordination degree is not high in some years, the coupling and coordination degree between digital industrialization and industrial digitalization in Jiangsu Province has been increasing year by year^[2]. Song *et al.* found that digital industrialization has significantly promoted the improvement of total factor productivity in China's industrial enterprises, but there are regional and industrial differences in development^[3]. Li and Zhou used a coupling coordination degree model to measure industrial digitalization, digital industrialization, and high quality. The coupling degree between industrial digitalization and digital industrialization has been found to be the highest, while the coupling degree between industrial digitalization and digital industrialization is the lowest^[4]. Gao and Li found that there are significant interregional differences in the coupling and coordination of digital industrialization and industrial digitalization in the eastern, central, and western regions of China, with the largest regional differences in the eastern region^[5]. (2) Discuss from the perspective of high-quality regional development and formulate countermeasures and suggestions. Zhang and Jiang proposed a path between data and traditional industries through exploring the elementization of data^[6]. Zhang *et al.* found that both industrial digitalization and digital industrialization have a positive impact on economic growth, mainly manifested in spatial spillover effects and the greater contribution of digital industries to improving economic growth efficiency^[7]. (3) Propose countermeasures and suggestions from the study of patterns and paths. Li and Huang conducted research on the patterns of industrial digitalization and digital industrialization using quadrant matrices. They analyzed the influencing factors and proposed countermeasures and suggestions to strengthen the construction of digital infrastructure and promote the development of leading industries^[8]. Qin *et al.* believed that insufficient infrastructure, lack of innovation, and insufficient utilization of digital resources are the main factors affecting digital industrialization. The development of digital industrialization should be promoted by consolidating the foundation, strengthening applications, highlighting accumulation, and optimizing policies^[9]. Du proposed promoting the integration of industrial digitalization and digital industrialization, mainly through methods such as non-equilibrium, fusion, and matching^[10]. Yang believed that it is necessary to accelerate the improvement of infrastructure construction, promote innovation in digital industrialization, and deepen the digitalization of industries in different regions^[11]. Ren proposed six paths to promote the coordinated development of industrial digitalization and digital industrialization based on existing research^[12].

At present, promoting high-quality development has become a common consensus in the industry and academia. The full utilization of numbers as the 'fourth factor of production' has become an important component in the selection of high-quality development paths. However, how to better utilize the digital

economy to promote high-quality development? There are still some unresolved issues, such as the mechanism of interaction between industrial digitalization and digital industrialization and matching and coupling mechanisms, which make this study have certain space and value.

2. Research on the interactive mechanism between industrial digitalization and digital industrialization

2.1. The mechanism by which industrial digitalization promotes the development of the digital industry

Industrial digitalization refers to the use of data production factors to change enterprise relationships, enhance basic capabilities, and improve efficiency within the industry. The driving role of industrial digitalization in the digital industry mainly includes five aspects: firstly, providing application scenarios. The core product provided by the digital industry is data, which needs to be applied in physical industries in order to realize its value. Secondly, the industry extensively applies data, forming new data assets and promoting the continuous upgrading of data platforms. During the use of the platform. Generating a large amount of data streams will form new data assets, promoting the improvement and functionality enhancement of the platform. Thirdly, realize the value of data resources. Data can only generate value and provide compensation when it is used. The realization of data asset value depends on the value-added of all enterprises (users) that use data. Without users, there will be no value. Fourth, promote technological upgrading. The realization of the value of data resources will provide support for the technological upgrading of the digital industry, forming a driving force for technological upgrading. Fifth, during the use of the platform, users will generate new data demands, which will provide direction for the digital industry and create external tension.

2.2. The mechanism of promoting industrial digitalization through digital industrialization

Digital technology itself has characteristics such as connectivity effect, spillover effect, and matching effect. Digital technology will have profound economic and social impacts in its own industrialization process. Firstly, promote the innovation of production methods. The traditional production method is characterized by a “single chain” production with large-scale and standardized assembly lines, which achieves technical efficiency through division of labor and specialization. In the process of digital technology industrialization, decentralized and personalized production has gradually adopted traditional production methods, which achieve efficiency through timely, diversified, and distributed production. Secondly, the emergence of platforms has driven changes in organizational forms. The traditional chain production corresponds to a chain organizational form, where upstream and downstream enterprises in the industry form a relatively regular chain arrangement and combination. Digital platforms will form a “tower + decentralized” network collaboration approach. Enterprises with innovative capabilities and the use of digital technology are at the forefront, driving numerous related enterprises to overcome spatial limitations through accumulation and radiation effects, thus forming a new organizational form characterized by “network + collaboration.” Thirdly, the spillover effects of digital technology promote the improvement of overall industry technological efficiency. The platform will generate spillover effects of knowledge and technology, leading to an improvement in the efficiency of the entire industry chain in the process of industrial digitalization. Fourth, enhance industrial competitiveness. The enhancement of innovation capability and the acceleration of knowledge and technology dissemination will lead to the continuous improvement of industrial competitiveness. Fourthly, the industrialization of digital

technology will elevate the industrial hierarchy. Applying digital technology to traditional industries, breaking down barriers between upstream and downstream industries, and promoting the intelligent development of industries. At the same time, it will also give rise to new formats or industries that can fundamentally change their position in the global value chain and promote the upgrading of industrial levels. Fifth, with the emergence of digital platforms, traditional barriers to production, consumption, and transactions in terms of geography and space caused by information are being reduced and lowered. While addressing the demand for modern logistics information, the development of traditional industries is being promoted by reducing transaction costs. This process will create a pressure mechanism to enhance the digitalization level of traditional enterprises.

3. The mechanism and path of coupling industrial digitalization and digital industrialization

The promotion of high-quality development in the digital economy relies on the high-level coupling of industrial digitalization and digital industrialization. This coupling can be low-level, built on a simple supply-demand basis with data as the product. It can also be a high-level coupling characterized by “intelligence level,” including data infrastructure, data technology, data platforms, data value, etc. Different degrees of coupling can form a “lock-in effect,” where low-level digital industries providing low-level digital products can lead to low quality, low efficiency, and low value of industrial digitalization, thereby reinforcing the results of low-level industrial digitalization. The digitalization of industries at the same high level leads to enormous value, significant technology spillover effects, and an increase in data assets, which will result in the development of high-level digital industries, thereby enhancing the effect. This type of “low-level lock-in” or “high-level lock-in” determines a region’s level of digitalization and whether it can form a comparative advantage in digital technology, thereby having a significant impact on high-quality development.

3.1. Coupling based on the supply and demand of digital products

The digital industry provides digital products to form digital supply, and industrial digitalization drives the process of digital transformation to generate digital demand. When digital demand matches supply, the regional digital market will reach an equilibrium state. In this state, coupling only refers to the realization of digital coupling in terms of scale, structure, and value, and users can only use existing data resources to pay fees; Platforms and digital enterprises provide data and receive corresponding rewards. The production of data is a one-way chain, which is a relationship between application and being applied, service and being served.

3.2. Coupling based on digital infrastructure

Digital infrastructure determines the production, trading, and consumption of data. The supply of data elements is affected by the regional digital infrastructure situation (including hardware, software, open source protocols, standard specifications, mechanism design, etc.). Data production is a complex process that is built upon existing software and hardware foundations. The network and computing power have a certain degree of determination; At the same time, data accumulation, calculation, transmission, application, circulation, security protection, value realization, etc. will also affect the supply of data. At the same time, in the process of industrial digitalization (application of data), corresponding infrastructure also needs to be implemented, including network security, data availability, data reliability, etc. The coupling at this level mainly refers to the ability of digital infrastructure to support the requirements of industrial digitalization, while also effectively supporting the development requirements of digital industries.

3.3. Coupling based on digital technology

Electronic information manufacturing, telecommunications, software and information technology services, the Internet, and other industries, specifically covering technological progress in 5G, integrated circuits, artificial intelligence, big data, cloud computing, blockchain, and other fields, especially technological breakthroughs such as cloud computing, mobile Internet, big data, human intelligence, and so on. On the one hand, it has solved the problem of technical foundation and new momentum of digital industrialization development; on the other hand, it has also solved the problem of application in the process of industrial digitalization. Good digital technology is not only the basis of industry, but also the basis of application, and must be an important influencing factor of the coupling between the two.

3.4. Coupling based on spatial separation and industrial layout

The traditional industrial layout emphasizes the concept of space and requires the spatial distribution of upstream and downstream industries in the industrial chain. It emphasizes the core of the axis and the distribution of points according to the axis. In this process, the issue of commuting costs needs to be considered. The traditional industrial layout emphasizes the center-periphery relationship. Based on the digitalization of industries, the industrial layout breaks through the limitations of spatial distance and can be more dispersed and rationalized, thereby better promoting regional balanced development and ultimately achieving overall integration in industrial layout. For example, in China's "East Digital West Computing" strategy, the eastern region has become the center of the digital industry, but the western region has relatively stable hydropower resources, and computing power is distributed in the western region. This can also leverage the comparative advantages of the western region to promote the development of the eastern and western regions from polarization to balance.

4. Implementation paths of industrial digitalization and digital industrialization coupling

4.1. Promoting the coupling of industrial digitalization and digital industrialization through the path of "industry + integration"

Accelerate the digitalization process of enterprises, connect business process data channels, improve enterprise digital infrastructure, improve enterprise business processes through data, enhance enterprise digital transformation capabilities and intelligence levels. Accelerate the digitalization process of the industrial chain, and use data to drive the transformation and upgrading of the entire industrial chain and supply chain of traditional industries. At the macro level, it is necessary to promote the deep application and integration of digital technology in various links and fields of the industry, leverage the value creation role of data elements, and promote the connection between the innovation chain and the industrial chain. At the micro level, it is necessary to support reality

Leading enterprises in the industrial chain of the economy are building digital collaborative innovation platforms, constructing micro mechanisms for industrial digitalization, and driving upstream and downstream supporting enterprises to accelerate digital transformation.

4.2. Promoting the coupling of industrial digitalization and digital industrialization through the path of "leading enterprises + regions + collaboration"

In the process of high-quality regional development, attention should be paid to the penetration and integration

of digital technology and traditional industries to improve the digital quality of industries, achieve synergy in the digital transformation of traditional industries across the entire industry chain, and promote the realization of high-quality development. Promote the matrix construction of the coupling between industrial digitalization and digital industrialization, with a focus on business scenario-based solutions as the link and lever, to leverage the digital industry and the digital transformation of thousands of industries, forming a matrix effect. Using leading enterprises as carriers, we aim to create a “tower top” demonstration effect and enhance the digital capabilities of enterprises. At the same time, filling in the gaps in regional development, promoting the gradual transition of regional development from non-equilibrium to equilibrium through the development of digital agriculture and smart agriculture. Focusing on digital agricultural experimental and research bases, promoting the use of agricultural technology to enhance the level of agricultural intelligence and improve agricultural production efficiency. Focusing on digital transformation in the field of agricultural circulation, utilizing digital e-commerce platforms to reduce the time and spatial distance of agricultural circulation, and building an integrated two-way urban-rural circulation system.

4.3. Promoting the coupling of industrial digitalization and digital industrialization through the path of “infrastructure projects + optimizing digital ecology”

We attach great importance to the important role of digital infrastructure construction projects in coupling. Strengthen the construction of digital infrastructure, promote the digital upgrading of industrial clusters, integrate information technology and various resources, enhance basic capabilities in the process of digital industrialization, promote the matching of production and application, and improve the coupling between supply and demand. Promote the integration of the innovation chain, supply chain, industry chain, talent chain, and technology chain, optimize the digital ecosystem, and promote the coupling of industrial digitalization and digital industrialization. Promote the integration of industrial digitalization and digital industrialization through a good ecosystem. In this process, environmental ecology, service ecology, and policy ecology are also important drivers for promoting the integration of the two, further promoting the optimization of the business environment, gradually forming a favorable environment system for digital entrepreneurship and innovation, promoting the incubation of new digital technologies and applications, and building a good service system that is conducive to the growth and strengthening of the digital industry. By constructing a market-oriented service and public service dual-wheel-driven service system, we focus on building a large group of digital solution suppliers, guiding the development of lightweight, easy-to-maintain, low-cost, one-stop solutions for the transformation requirements of small and medium-sized enterprises, and enhancing the digital transformation service capabilities and international competitiveness of suppliers. At the same time, relying on top enterprises to build a digital collaborative platform, promoting the connection between services and digital platforms, and coordinating the integration of upstream and downstream enterprises in the digital industry.

5. Inspiration and suggestions

5.1. Increasing investment in digital infrastructure construction and creating comparative advantages in digital hard environment

Digital infrastructure, as the “highway” of the digital economy, requires increased investment in infrastructure to solidify the foundation for the development of the digital economy. Infrastructure such as network coverage, data centers, and cloud computing platforms needs to be continuously invested to gradually form comparative

advantages in the development and application of digital industries. At the same time, attention should be paid to the construction of data security governance and supervision facilities to ensure the safe circulation and application of data. To provide a hardware environment for the development and value realization of the digital industry, and to provide a solid application foundation for the digitalization of the digital industry.

5.2. Establishing a system and mechanism for realizing the value of digital products, promoting the benign promotion of production and application

Basic digital products can be public welfare, and the government provides these products by formulating policies to ensure the supply and reasonable use of basic data. At the same time, the government ensures the value realization of these digital products through taxation and other means. It can also be commercial, provided by enterprises, and the government formulates policies to ensure reasonable compensation for digital providers. Professional digital products should generally be provided by enterprises and commercial platforms. The government needs to establish strict intellectual property protection and payment mechanisms for digital products. At the same time, data supply enterprises also need to design reasonable technologies that can ensure value realization and ensure reasonable compensation for digital product suppliers.

5.3. Promoting the coupling of industrial digitalization and digital industrialization with the core of enhancing the industrial chain

Promote chain supplementation, upgrading, and strengthening, create comparative advantages in the industrial chain, and promote the integration of industrial digitalization and digital industrialization. Through regional cooperation, we aim to complete the “supply chain” of the digital industry chain, clarify the position and role of each region in strengthening the industry chain, and strengthen the industry chain by enhancing regional cooperation. By enhancing the “three core” values and completing the “chain upgrading” work, namely core technologies, core platforms, and core products, we aim to elevate our position on the value chain in promoting the integration of industrial digitalization and digital industrialization. By enhancing the competitiveness of digital and its related industries, as well as digital application industries, we can achieve a “strong chain.” Continuously expanding the accumulation and radiation effects through digital technology innovation and platform technology innovation of leading enterprises, driving the improvement of competitiveness in related industries. By improving the scale and quality of digital infrastructure, digital technology, digital transmission, and digital applications, we can promote the enhancement of industrial competitiveness.

5.4. Building an integrated policy system to promote the coupling of industrial digitalization and digital industrialization

Through policy guidance and support, achieve the comprehensive integration of digital technology and the real economy, and promote the high-quality development of the digital economy. Strengthen the supply of guarantee systems, enhance the improvement of the policy system for digital industrialization and industrial digitalization, and provide institutional guarantees for the coupling of the two. Strengthen the supply of cluster systems, promote the innovative development of digital industry clustering, accelerate the construction of characteristic digital industry clusters, and increase policy support for digital industry clusters. Strengthen the supply of environmental regulations, continuously optimize the development environment of the digital industry, collaborate to improve the basic system for data development and use, and promote data Optimization of element configuration and realization of value.

6. Conclusion

Industrial digitalization and digital industrialization are coupled based on conditions and prerequisites related to supply and demand, digital technology, infrastructure, and spatial distribution. A path to integration is formed through industrial integration, collaboration between leading enterprises and regions, and the construction of a digital ecosystem. Based on China's development reality, this paper believes that it is necessary to further optimize digital hardware construction, promote the realization of digital value, enhance the digital industrial chain and value chain, and optimize the supporting policy system.

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