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Research on the Reconstruction of Global Industrial Chains and the Digitization of Chinese Industrial Chains

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Abstract. Under the intertwined influence of multiple factors, such as the vigorous rise of new technological revolution, the increasingly fierce competition among major countries, and the continuous impact of the COVID-19, the configuration logic of the global industrial chain is accelerating its restructuring at an unprecedented speed. At present, the development of global industrial chains presents significant new features such as deep digital integration, accelerated green transformation, strengthened regional cooperation, and prominent trends in short chain specialization. In this complex and ever-changing international context, the digital transformation of China's industrial chain is steadily advancing, driven by two key forces: the digital demand that continues to extend from the consumer end to the industrial end, and the precise empowerment of enterprises through platform based models. These two forces work together to promote the formation of a close cooperation system covering the entire value chain of research and development, production, and sales in China's industrial chain. This article will focus on the core issue of global industrial chain reconstruction and digital transformation of China's industrial chain, deeply analyze their characteristics, and explore the two-way interaction between the two from the perspective of mathematical economics, in order to explore the optimized development path of China's industrial chain.

Keywords: Global industrial chain restructuring, industrial chain, digitization.

1. Introduction

The "14th Five-Year Plan" identifies "advancing the sophistication of industrial foundations and modernizing industrial chains" as a significant indicator of new achievements in Chinese economic development, explicitly setting the goal of accelerating the development of a modern industrial system. As an important component of the global industrial chain, the level of modernization of the Chinese industrial chain depends not only on its conditions and the implementation of development strategies, but also on the international political and economic environment. Currently, the fourth round of global industrial chain restructuring is accelerating amidst great power competition. This restructuring not only alters the global industrial layout but also poses new challenges to the security of industrial chains across countries. It compels China to accelerate the pace of industrial chain upgrading, and enhances the modernization and internationalization of its industrial and supply chains to maintain an invincible position in great power competition [1].

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Under the impact of the comprehensive escalation of great power competition between China and the United States, coupled with the COVID-19 pandemic, the paradigm of international division of labor based on global value chains and integrated production networks has exposed its inherent vulnerabilities. Certain links in the global industrial and supply chains have been obstructed and interrupted, exhibiting characteristics of short chains and regionalization [2]. Amidst the unprecedented changes in the world over the past century, external uncertainties have significantly increased, and the security situation of industrial chains has become complex and volatile. This amplifies the triple pressures faced by the Chinese economy, namely "demand contraction, supply shock, and weakened expectations." At the same time, it also raises new requirements for standing on a new stage of development to lead and shape a "safe, open, collaborative, and win-win" regional value chain [3,4].

Facing the challenges posed by the external environment, a new round of technological revolution centered around digital technology has provided a breakthrough for the upgrading of the Chinese industrial chain. The digital restructuring and upgrading of the industrial chain not only facilitate the creation of more value for businesses, but also accelerates the transformation of production methods, promotes the enhancement of social productivity, and improves people's well-being. China possesses a nationwide system advantage and the scale of its super-large market, coupled with its partial leadership in data storage and digital technology application. So, digital restructuring and upgrading of industrial chains becomes a feasible path to achieve Chinese modernization. This paper summarizes the characteristics of global industrial chain restructuring and the development features of Chinese industrial chain digitization and analyzes their interrelationship from the perspective of the digital economy. It explores the path for enhancing Chinese industrial chain optimization, providing a theoretical basis for the continuous promotion and expansion of the Chinese path to modernization under the new nationwide system of scientific and technological innovation.

2. Reconstruction of the global industrial chain

2.1. Concept definition

The restructuring of the global industrial chain refers to the systematic adjustment of the spatial layout, organizational form, and value distribution system of the industrial chain, which is driven by the profound changes in the global political and economic landscape and the technological revolution. Unlike the previous three reconstructions, which were primarily driven by efficiency optimization, the fourth reconstruction places greater emphasis on safety and resilience. With the vigorous rise of a new round of technological revolution and industrial transformation globally, and influenced by intensified competition among major powers and the impact of the COVID-19 pandemic, some countries begins to place greater emphasis on forming autonomous and controllable industrial chains, ensuring the complete operation of the industrial chain and reducing reliance on cross-border production, advocating for the "industrial reflux [5].".

Firstly, spatial restructuring is underway. Driven by geopolitical conflicts and technological revolutions, the global production network is shifting from an efficiency-first model heavily reliant on cross-border division of labor to a regionalized layout dominated by security and resilience. Typical examples include the United States promoting the repatriation of manufacturing industries to North America and China strengthening the Asia-Pacific supply chain network through the Regional Comprehensive Economic Partnership (RCEP). Meanwhile, emerging economies such as ASEAN and India are undertaking industrial transfers based on cost advantages, forming a new pattern of "diversified regional clusters" [6]. Alongside spatial layout adjustments, technological changes are profoundly reshaping the industrial chain. The industrial internet and artificial intelligence are driving

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the trend towards distributed manufacturing and shorter supply chains, but the competition for data sovereignty has exacerbated the fragmentation of global digital governance. Furthermore, the goal of carbon neutrality is to accelerate the green transformation of the industrial chain. CATL's establishment of factories in Europe to reduce its carbon footprint and BASF's adjustment of its high-energy consumption production line layout reflect the global competition in the new energy industry chain and the spatial reconfiguration of high-carbon industries. Against this backdrop, multinational corporations balance security and efficiency through a "resilience-first" strategy, while sovereign states engage in rule-based games through technological blockades and independent innovation. This restructuring process is essentially a superimposed resonance of technology, geopolitics, and sustainable development goals, reshaping the power distribution and spatial organization of the global value chain.

2.2. Characteristic

With the in-depth development of a new round of technological revolution and industrial transformation, emerging technologies and their industrial applications are driving the accelerated restructuring of the international production and trade system. On the one hand, the global industrial chain is exhibiting new trends such as digitization, greenization, and integration [7]. On the other hand, the global industrial chain is characterized by regionalization, heterogeneity, and short-chainification.

2.2.1. Digitization, greenization, and integration

The digital revolution is reshaping the global industrial landscape with unprecedented breadth and depth. The traditional advantages of factors such as labor, land, and capital in the global industrial chain are relatively weakened. New industrial and supply chains, centered around digital and intelligent technologies, are reshaping the global production function [8]. The new round of technological revolution and industrial transformation is giving birth to future industrial clusters. Led by digital technology, the integration of digital industrialization and industrial digitization is empowering the restructuring of the global industrial chain. Massive data elements, integrating production and consumption ends, are being invested in the development of new agriculture, new mining, new manufacturing, new finance, and new business. Through self-organization, networking, distributed, and platform-based reengineering, the global industrial chain will be endowed with new characteristics such as deep integration of production and services, blurring boundaries between upstream and downstream, and coexistence of mass production and customization.

Greenization represents another clear trend in the restructuring of the global industrial chain. Countries are actively pursuing cleaner energy sources, seizing opportunities to drive green technology innovation, developing emerging green industries, creating green jobs, and ensuring that green growth becomes a lasting driving force for economic and social transformation. The greenization of the industrial chain should be premises on energy transformation and aim to achieve green reengineering across the entire chain and product lifecycle, with concerted efforts made at the technological, structural, and institutional levels to reduce emissions.

2.2.2. Regionalization, heterogeneity, and short-chainification

The fourth round of global industrial chain restructuring, influenced by great power competition, is more susceptible to the push of national political forces. It exhibits characteristics such as politicization, anti-globalization, accelerated impact of the pandemic, and fragmented governance

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systems, disrupting the traditional "flying geese model" of division of labor [9]. The underlying logic shifts towards emphasizing the security and stability of the industrial chain, with competition for control and strategic advantage in the industrial chain. This restructuring drives the evolution of the global production network towards "limited globalization", manifested in localized production, nearshore outsourcing, diversified layout, and fragmented technological alliances, forming a new type of regional industrial ecosystem that rebalances safety and efficiency.

Furthermore, due to differences in innovation capabilities, participation, types of leading industries, and positions in the global value chain, economies around the world are affected differently when facing external uncertainty shocks. Economically developed regions participate more deeply in the division of labor within the global industrial chain. On the one hand, this enables them to better compete for the world's most cutting-edge technologies and keep pace with the times. On the other hand, when the production needs of key links or core components cannot be met, it will have a significant negative impact on enterprises in the downstream industrial chain. Consequently, some countries or regions that occupy advantageous areas and key links in the industrial chain may gain more employment opportunities, technological advancements, and industrial upgrades from the restructuring of new industrial chains. On the other hand, some countries or regions that are at the edge of the industrial and value chains may lose their original market share and economic benefits, even worsening their economic, trade, and technological positions globally.

Impacted by the pandemic and influenced by policy adjustments in various global economies, multinational corporations have become increasingly cautious about their global investments and layouts. At the same time, to ensure the safety and stability of the industrial chain, they slow down the progress of investment activities and reduce the length of the industrial chain, exhibiting a trend of short-chainification year by year. The "short-chainification" of the global industrial chain is highly susceptible to policy shocks from various countries, including trade policies, tax policies, environmental protection policies, and other policy challenges that may have a significant impact on the production and operation of enterprises.

3. Digitization of Chinese industrial chain

In recent years, the digital transformation of the Chinese industrial chain has gradually extended from the consumer side to the entire industrial chain. Relying on the vast domestic demand market and a mature digital consumption ecosystem, new-generation information technologies such as big data, artificial intelligence, and 5G are accelerating their penetration into all industrial links, including research and development design, intelligent manufacturing, supply chain management, and after-sales service, thereby establishing a digital collaborative system covering the entire value chain of "research-production-supply-sales-service". Based on Chinese experience, the digital transformation of the entire industrial chain presents the following two major characteristics [10].

3.1. Extending from the consumer internet to the industrial internet

As the world's largest consumer internet market, China's vast digital consumption scale has not only nurtured platform enterprises such as Alibaba and JD.com, but also laid a solid foundation for the development of the industrial internet in terms of data accumulation, technological iteration, and model innovation.

The rapid development of the consumer internet has spurred the emergence of key technologies such as big data analysis, cloud computing architecture, and artificial intelligence algorithms. Taking Alibaba as an example, based on the massive consumer data accumulated on its e-commerce platform and its technological capabilities, it launched ET Industrial Brain in 2017, successfully transferring

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digital technology from the consumer sector to industrial scenarios. Currently, the platform has formed 3 major industry knowledge graphs, 7 industry data models, and 19 business models. This extension from the consumer internet to the industrial internet possesses three notable advantages. Firstly, it lowers the threshold for technology application, making digital technologies that have been validated in the consumer sector more readily accepted by the industrial side. Secondly, it forms a data loop, allowing consumer-side data to feed back into industrial decision-making. Thirdly, it creates synergistic effects, with the infrastructure of the consumer internet directly serving the digital transformation of industries. Currently, this extension model has expanded from e-commerce platforms to logistics, finance, and other fields, reshaping the digital ecosystem of the Chinese industrial chain.

3.2. Expanding from internal digitization to platform empowerment of industrial chain

In recent years, a group of leading manufacturing enterprises has reshaped the industrial chain collaboration model by internal digitization and experiential productization and platformization, driving the in-depth development of digital transformation across the entire industry. This transformation path exhibits distinct phased characteristics. Initially, enterprises often commence with internal digitization transformation. For instance, Haier initiated its smart manufacturing transformation in 2012, achieving a 30% increase in production efficiency and a 20% reduction in defective product rate through the construction of digital workshops. With the accumulation of internal digitization experience, leading enterprises began to abstract mature solutions into platform capabilities. Haier's "Kasuo" industrial internet platform innovatively adopts a "parent platform + X + N" architecture, transforming intelligent solutions validated in the home appliance industry into configurable industrial apps. To date, this model has been successfully replicated in 15 industries such as ceramics and glass, forming cross-industry empowerment capabilities. The key to this model lies in achieving digital precipitation and platformization sharing of manufacturing knowledge, enabling small and medium-sized enterprises to obtain validated digital solutions at lower costs.

The practice of SANY Group's "Genyun" platform demonstrates another path of empowerment. By connecting 720,000 industrial devices, the platform has established a digital service system covering the entire lifecycle of equipment. In the construction machinery industry, the remote operation and maintenance service provided by the platform has reduced equipment failure by 60%; In the textile industry, the intelligent production scheduling system driven by AI has helped enterprises increase their capacity utilization rate by 25%. In conclusion, the data exchange and business collaboration among various links of the industrial chain are achieved through the industrial Internet platform.

The transformation from internal digitization to platform-based empowerment within enterprises embodies three major innovations in the digital transformation of the Chinese industrial chain. Firstly, there is innovation in the knowledge reuse mechanism, which transforms specific corporate experiences into general industry capabilities. Secondly, there is innovation in service models, which lowers the threshold for digital transformation of small and medium-sized enterprises through platformization. Thirdly, there is innovation in ecosystem construction, forming a digital service ecosystem centered around platforms. This transformation model is being rapidly replicated in key industries such as construction machinery, home appliances, and electronic information, pushing Chinese overall digital transformation of the manufacturing industry into a new stage.

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4. The bidirectional interaction between the reconstruction of the global industrial chain and the digitization of Chinese industrial chain

4.1. The challenge of global industrial chain restructuring to the digitization of the Chinese industrial chain

Since the reform and opening, China has promoted the rapid development of its manufacturing industry by deeply integrating into the global industrial and supply chain systems. However, with the complex changes in the international environment and the adjustment of the domestic economic structure, the security and resilience issues of the Chinese industrial chain have gradually become prominent.

Firstly, Chinese long-term "low-end embedding" in the global industrial chain leads to a decline in the security of the industrial chain. For a long time, China has mainly undertaken the production links in the global industrial chain, relying on low-cost labor and resource inputs. However, with the gradual disappearance of the demographic dividend, this model becomes unsustainable. Some industrial chains rely too heavily on a single supplier or product, leading to a significant increase in the risk of industrial chain disruption in the face of external shocks. In addition, the continuous rise in comprehensive production and operation costs also exacerbates the pressure on the relocation of industrial chain links. This rigid dependence and lack of resilience make the Chinese industrial chain particularly vulnerable to international competition and changes in the external environment. Secondly, technological shortcomings in industries restrict the upgrading and upgrading of Chinese industrial and supply chains. Chinese overall technological level has not yet reached the global frontier, and the lack of core technologies and heavy reliance on imports for high-tech intermediate inputs have placed China in a passive position in international competition. At the same time, export restrictions on key technologies imposed by Western countries have further exacerbated the risk of "chain breakage" and affected the smooth operation of domestic industrial chains. This technological shortcoming not only restricts the upgrading of the industrial chain but also weakens Chinese bargaining power in the global industrial chain. Thirdly, the leading power of innovative-driven industrial chains is relatively weak. In 2024, Chinese R&D's (research and experimental development) intensity has shown a steady increase as shown in Figure 1, with R&D intensity reaching 2.68%, surpassing the average level of EU countries (2.11%), and further approaches the average level of OECD countries (2.73%), among the major economies globally ranked 12th. However, the proportion of China's investment in basic research remains relatively low. The weakness of basic research has led to China's lack of leadership in the formation of high-tech and emerging industry chains, with the country more often in a passive follow-up position. The rise of global trade protectionism and unilateralism has further exacerbated the uncertainty of global supply chains, threatening the integrity of Chinese industrial chains. Furthermore, the mismatch between supply and demand in the high-quality internal circulation, structural contradictions in the external circulation, and imbalances in the allocation of innovation factors also contribute to the "blockage" of Chinese industry chains. Strengthening the digital economy to enhance the security and resilience of industry chains becomes an urgent and practical necessity.

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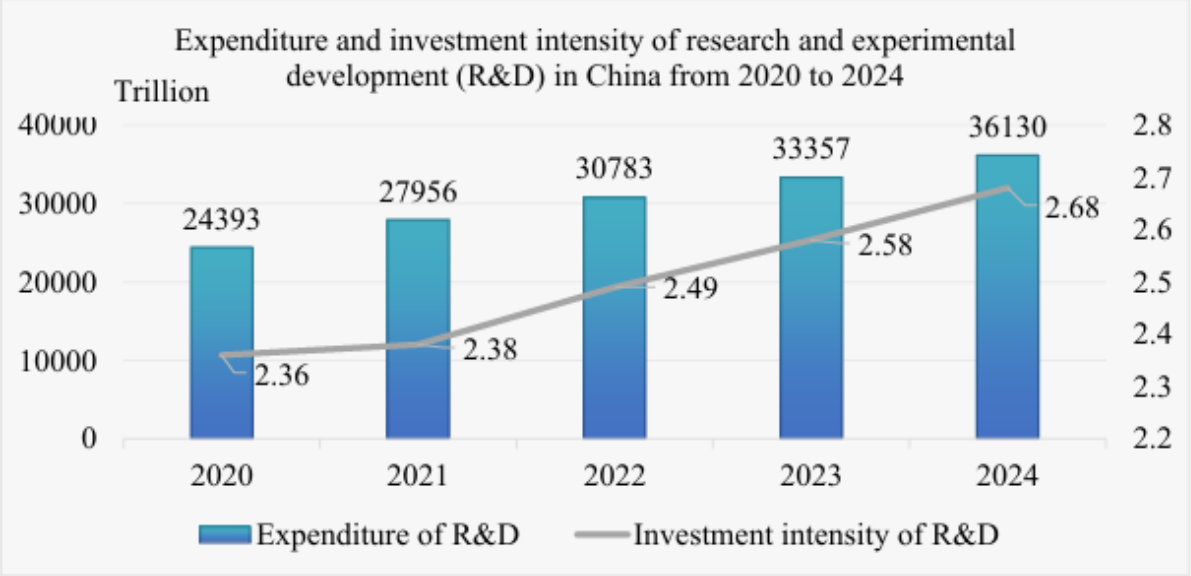

Figure 1: Expenditure and investment intensity of research and experimental development (R&D)

4.2. The reshaping of the global industrial chain by the digitization of Chinese industrial chain

The reshaping of the global industrial chain by the Chinese digitization process is essentially a systematic reconstruction of technological standard export, business model innovation, and geoeconomic power. This impact is manifested not only in the deep penetration of technological rules and industrial ecology, but also in the dynamic adjustment of the power structure of the global value chain.

4.2.1. New model output: dual-track breakthrough of technical standards and green collaboration

In the field of digital governance solutions, China establishes a third path distinct from that of the United States and Europe through its "tiered and categorized" cross-border data management model. When participating in the negotiations for the Digital Economy Partnership Agreement (DEPA), China proposed a solution for balancing data sovereignty and circulation that circumvents the strict restrictions of the EU's General Data Protection Regulation (GDPR), providing a governance template that balances security and efficiency for developing countries. This practice of the "Chinese standard" is implemented in ASEAN countries. In the Indonesia-Jakarta High-Speed Rail project, China integrates and exports communication systems and data security protocols, forming a new cooperation model that bundles technology and rules.

In terms of green digital collaboration, China pioneers a system integration model of "photovoltaic + energy storage + smart grid". The "Lighthouse Factory" built by CATL in Hungary not only achieves full digitization of battery production but also enhances the green electricity utilization rate of the factory to 85% through an energy management system. This integrated solution of "zero-carbon manufacturing + intelligent operation and maintenance" is being regarded as a benchmark for decarbonization transformation by European automobile companies. Furthermore, the "Digital Silk Road" project led by China promotes off-grid solar smart microgrids in Africa, combining mobile payments to achieve an energy-finance closed loop, thereby reshaping the global layout of the traditional energy industry chain.

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4.2.2. New power structures: consumption chain reconstruction and asymmetrical transition of developing countries

Digital platforms disrupt the Western centralized e-commerce monopoly through the restructuring of the consumption chain. TikTok e-commerce, leveraging algorithmic recommendations and social fission mechanisms, achieves a "hyper-local" supply chain response with 48-hour delivery in the Southeast Asian market. The decentralized traffic distribution model of TikTok has disrupted Amazon's search-driven e-commerce logic. In 2024, TikTok Shop's Southeast Asian Gross Merchandise Volume (GMV) surpassed $23 billion, compelling Amazon to adjust its regional warehousing strategy and shaping a new power dynamic where "Chinese platforms define the rules and local businesses undertake the services.".

For developing countries, the Chinese "digital leapfrogging" experience provides a nonlinear upgrading path. Ethiopia has learned from the Chinese industrial internet model to construct a digital textile park, which has reduced the defective rate of products from 12% to 3% through the AI quality inspection system deployed by Alibaba Cloud. At the same time, it has integrated with real-time order system, achieving a breakthrough in the short-chain transformation of "Made in Africa - Direct Supply to the World". The key to this model lies in the trinity output of "technology-capital-market": China provides digital infrastructure, cross-border e-commerce platforms to access global demand, and industrial funds to guide local production capacity upgrading, forming an alternative to the traditional "flying geese model".

4.2.3. Restructuring effect: power transition and rule game

This reshaping is altering the power dynamics of the global industrial chain. In the semiconductor sector, Huawei's Kunpeng ecosystem has attracted over 1,000 global developers through its open-source architecture, and its "technical Lego" model is challenging ARM's closed ecosystem. By 2025, Kunpeng servers will have been deployed globally more than one million units, offering alternative options in key industries such as finance and government affairs. Simultaneously, the "de-weaponization" strategy of digital technology output contrasts with Western technological blockades, reinforcing developing countries' technological dependence on China and their political cohesion.

However, this restructuring also faces dual challenges: on one hand, the United States and Europe are constructing digital alliances that exclude China through "friendly shoring," such as the US's "Indo-Pacific Digital Agreement" restricting market access for Chinese cloud service providers; on the other hand, some developing countries are concerned about "digital colonization," with Indonesia, for instance, demanding that TikTok divest its e-commerce business to protect local small and medium-sized enterprises. China needs to seek a more refined balance between technology output and local adaptation to consolidate its dominant position in the restructuring of the global industrial chain.

5. Conclusion

The study on the interactive relationship between the restructuring of the global industrial chain and the digitization of the Chinese industrial chain reveals the complex interplay of technological revolution, geopolitics, and national strategy. The research indicates that China plays a dual role as both a "passive responder" and an "active shaper" in the restructuring of the global industrial chain: while the technological blockade imposed by the West and the "de-risking" of supply chains force China to accelerate its core technology research, China reshapes the rules and power structure of the global industrial chain through digital technology exports, green collaborative models, and industrial internet platforms. This bidirectional interaction demonstrates that the restructuring of the global

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industrial chain is not a one-way "de-sinicization", but rather a dynamic rebalancing under the multilateral game between China, developed countries, and emerging economies.

Future research still needs to focus on three major directions. Firstly, the boundary of technological politicization, exploring the balance between digital technology autonomy and global cooperation, and avoiding the fragmentation of the global innovation system. Secondly, green digital collaboration, analyzing how the global layout of Chinese new energy industry chain under the goal of carbon neutrality is compatible with European and American carbon tariff policies. Thirdly, a composite governance framework, constructing a global industrial chain governance system that takes into account safety, efficiency, and ethics, to address the institutional challenges of disruptive technologies such as generative AI and quantum computing. At the practical level, China needs to strengthen the "dual circulation" strategy's resilience. And optimizes resource allocation through projects such as "east data, west computing", while relying on multilateral frameworks such as RCEP and DEPA to participate in the formulation of digital rules, thereby promoting the construction of an inclusive global industrial chain ecosystem.

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