Review on Domestic and International Research on Transformation and Upgrading of the Manufacturing Industry

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Abstract. With the new round of global scientific and technological revolution and industrial change advancing rapidly, the new generation of information and communication, biological, new materials, new energy and other technologies continue to break through, and accelerate the integration with advanced manufacturing technology, which provides a historical opportunity for the development of high-end, intelligent and green manufacturing industry. This paper primarily introduces the overview of the development of domestic and foreign manufacturing industry, and summarizes the development process of domestic and foreign manufacturing transformation and upgrading, the policy documents introduced by countries in the transformation and upgrading of manufacturing industry, and its development focus. Finally, through the comparison of domestic and foreign manufacturing transformation and upgrading, it summarizes the advantages of domestic and foreign manufacturing transformation and upgrading and the problems it faces.

Keywords: Manufacturing Industry; Transformation and Upgrading; Intelligent Manufacturing.

1. Introduction

The course of development of the manufacturing industry is the result of the joint promotion of technological innovation and social demand. From the early handmade workshops, to the mechanized production during the industrial revolution, and then to the large-scale assembly line operation in the 20th century, the manufacturing industry has experienced the transformation from handmade to mechanization, automation and informationization. With the rise of computers and information technology, the manufacturing industry began to realize digital management, which improved production efficiency and product quality. Since the 21st century, the application of emerging technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI) has enabled the manufacturing industry to move towards intelligent manufacturing, and the production process

has become more intelligent and automated. At the same time, the trend of globalization has made the supply chain and market of manufacturing more internationalized, with product design, production, sales and service crossing national boundaries. In addition, the rising awareness of environmental protection has also prompted the manufacturing industry to develop in a green and sustainable direction, focusing on energy saving, emission reduction and resource recycling. Overall, the development of the manufacturing industry is an evolving process, which is closely linked to technological progress, market demand, environmental protection and other factors, and will continue to develop in the direction of greater efficiency, intelligence and environmental protection in the future.

The development profile of the manufacturing industry abroad reflects the trends of technological innovation, industrial transformation and globalization. From the perspective of technological advancement, the manufacturing sector is experiencing the fourth industrial revolution, or Industry 4.0, represented by the Internet of Things, artificial intelligence, 3D printing and advanced robotics, which has greatly improved production efficiency and product quality. The concept of smart manufacturing is being promoted globally and the emergence of a new global consumer class is expected to create new market opportunities for the manufacturing industry by 2025. Despite the challenges of the COVID-19 pandemic, the global manufacturing sector grew by 4.2% year-on-year in the first quarter of 2022, with North America and Asia & Oceania performing the best. The global supply chain is facing challenges such as issues with raw materials and product distribution, and the automotive manufacturing industry continues to experience a decline in production due to supply chain disruptions. At the same time, there are significant regional differences, with Asia and Oceania expanding their share of the global medium- and high-technology industry, while Latin America, the Caribbean, and Africa have a low share of medium- and high-technology industries, which hampers local economic development. In terms of labor markets, the manufacturing sector faces challenges in attracting and retaining talent, while also exploring the use of digital tools to enhance talent acquisition and considering leveraging the knowledge and experience of retired employees. Environmental sustainability is also receiving increasing attention, with the manufacturing sector striving to green production and recycle resources. In terms of policy support, in order to support growth and innovation in the manufacturing sector, policymakers need to have a comprehensive understanding of the different industry segments affecting the manufacturing sector and invest in key factors such as modernized infrastructure. Education and skills development are critical to the manufacturing sector, and policymakers and businesses are working to ensure that schooling matches the needs of employers. Digital transformation is another key trend in the manufacturing industry, including building model-based enterprises, leveraging the industrial metaverse to connect internal and external stakeholders across the globe, and improving efficiency. The global manufacturing industry is undergoing profound changes. Influenced by multiple factors such as the rise of reverse globalization and protectionism, the reconstruction of international economic and trade rules, the push by developed countries to relocate back to the industrial chain, and the accelerated advancement of a new round of scientific and technological revolutions, the future pattern of the global manufacturing industry and the industrial chain supply chain will be accelerated in the direction of regionalization, localization, diversification, and digitalization to adjust and reshape.

The transformation and upgrading of the manufacturing industry is a complex and multidimensional process, which involves many aspects such as technological innovation, industrial transformation and globalization. With the continuous progress of science and technology, the manufacturing industry is experiencing a transformation from traditional production methods to intelligentization, automation and informationization. Intelligent manufacturing, as the core of the transformation and upgrading of the manufacturing industry, emphasizes the integrated application of automation technology and data analysis. Through intelligent manufacturing, enterprises are able to achieve more accurate inventory management, improve production efficiency and product quality, while reducing energy consumption and resource waste. The transformation and upgrading of the manufacturing industry also includes the optimization of the supply chain, through digital tools to

improve the transparency and responsiveness of the supply chain, reduce logistics costs, and improve the flexibility and resilience of the supply chain. At the same time, the manufacturing sector is also transforming into green manufacturing, which includes adopting environmentally friendly materials, optimizing production processes to reduce waste and pollution, and improving energy efficiency. In addition, with the deepening of global economic integration, international cooperation in the manufacturing sector has become increasingly frequent, with enterprises sharing resources and technologies through cross-border cooperation in order to enhance competitiveness and market share. Talent training is also particularly important in this process, and education and training institutions are adjusting their curricula to train people who can adapt to new technologies and new production methods. Policy support is also an important driving force for the transformation and upgrading of the manufacturing industry. Many countries have introduced policies to support the transformation and upgrading of the manufacturing industry, including tax incentives, financial support, and research and development subsidies, in order to promote technological innovation and industrial upgrading in the manufacturing industry. Overall, the transformation and upgrading of the manufacturing industry is an evolving process, which is closely linked to technological progress, market demand, environmental protection and other factors, and will continue to develop in the direction of more efficient, smarter and more environmentally friendly in the future.

2. Transformation and Upgrading of Foreign Manufacturing

The transformation and upgrading of foreign manufacturing industries is moving in the direction of intelligence, automation and informationization. Technological advances, such as the Internet of Things, artificial intelligence, big data and cloud computing, are improving the efficiency and productivity of the manufacturing industry. Intelligent manufacturing not only optimizes the production process, but also reduces resource waste and promotes the green transformation of the manufacturing industry. On the supply chain management front, companies are responding to increasing supply chain disruptions by strengthening existing supplier relationships, diversifying supplier strategies, deploying digital tools to enhance supply chain visibility, and combining efficiency and resilience.

The transformation and upgrading of the manufacturing sector in the United States has been strongly supported by the Government and promoted through a series of policies and measures. These policies include tax incentives, financial subsidies, investment in research and development (R&D), talent cultivation, infrastructure development, market access protection, international cooperation and the building of an innovation system. Documents such as the *Strategy for American Leadership in Advanced Manufacturing* and the *National Quantum Initiative Act(NQI Act)* issued by the U.S. Government emphasize investment and support in areas such as smart manufacturing, advanced materials processing, the medical manufacturing industry, and electronic design and manufacturing. In addition, the United States has promoted the green and low-carbon transformation of the manufacturing industry through environmental regulations such as the *Clean Air Act(CAA)*. Despite protectionist tendencies, the U.S. seeks international cooperation in certain areas to share resources and technologies and to enhance the technological level and market competitiveness of its own manufacturing industry. The implementation of these policies has helped to promote the transformation and upgrading of the United States manufacturing industry and to improve its competitiveness and sustainable development.

The transformation and upgrading strategy for Japan's manufacturing sector was multifaceted, including strengthening technological innovation, upgrading the education and training system, promoting the industrialization of achievements, strengthening intellectual property protection, promoting green and low-carbon transformation, and enhancing international cooperation, among others. The Government of Japan had formulated a series of policies to that end, such as the *Economic Security and Guarantee Promotion Act*, which aimed to ensure economic security, including the safeguarding of key technologies and materials. In addition, the Government of Japan has promoted

the *Green Growth Strategy Through Achieving Carbon Neutrality in 2050* to promote the low-carbon development of industries, including accelerating the pace of "carbon neutrality" in manufacturing industries such as automobiles and storage batteries and semiconductors. Japan also focuses on upgrading product quality and technological innovation, emphasizes "craftsmanship spirit", and provides financing support to enterprises through policy financial institutions, such as the Japan Development Bank and the Japan Export-Import Bank. Together, these policies and measures have contributed to the transformation and upgrading of Japan's manufacturing sector, maintaining its edge in global competition.

The transformation and upgrading strategy of the European manufacturing sector focuses on improving competitiveness and sustainability. The implementation of the European Union's "reindustrialization" strategy has contributed to an increase in the share of exports of manufactured goods, particularly in areas such as pharmaceuticals, transport equipment, automobiles and steel, where the traditional advantages are evident. In the face of global economic challenges, the European Union had strengthened supply chain security, promoted a dual green and digital transformation, supported green technologies and industries through policies such as the *European Green Deal(EGD)*, and strengthened the research, development and application of digital technologies in order to enhance the intelligence of the manufacturing sector.

In addition, the European Union had introduced the concept of Industry 5.0, which emphasized a balance between economic value and eco-efficiency, promoted intersectoral cooperation, increased value chain resilience, purposeful digitalization and leveraged financial markets for transformation. Together, these policies and measures are driving the transformation and upgrading of European manufacturing with the aim of building a more resilient and sustainable industrial future. Through cooperation with global partners, the European manufacturing industry shares resources and technologies to enhance the competitiveness and influence of the industrial chain, and actively promotes the return of manufacturing to reduce dependence on external suppliers and strengthen the competitiveness of local industries. Specific policy documents include the *European Green Deal(EGD)*, the *Critical Raw Materials Act(CRMA)*, and the *Net-Zero Industry Act(NZIA)*, which reflect the EU's green and digital transformation These documents reflect the EU's emphasis on green and digital transformation and provide a policy framework and guidance for the future development of the manufacturing industry.

3. Transformation and Upgrading of Domestic Manufacturing

The transformation and upgrading of China's manufacturing sector is a key part of China's economic transformation, aimed at promoting the transformation of the traditional manufacturing sector in the direction of high-end, intelligent, green and integrated manufacturing through such strategies as technological innovation, industrial structure optimization, green and low-carbon development and industrial integration. This transformation has been strongly supported by the government, as reflected in policy documents such as *Made in China 2025*, and the *guideline on accelerating the transformation and upgrading of traditional manufacturing industries*, etc. These policies aim at encouraging enterprises to increase investment in R&D, enhance their innovation capability, optimize the product structure, improve the efficiency of resource utilization, and promote the development of industrial clusters by means of finance, taxation, and financial means. At the same time, talent training and international cooperation are being strengthened in order to enhance the international competitiveness and sustainable development of China's manufacturing industry.

Over the past decade, China has made great progress in the development of intelligent manufacturing through collaborative innovation among industries, universities and research institutes, demonstration and application by industrial enterprises, and joint promotion by the central and local governments. The supply capacity has been continuously improved, the market satisfaction rate of intelligent manufacturing equipment is more than 50%, and the number of system solution providers with main business income exceeding 1 billion yuan has reached more than 40. The support system

has been gradually improved, and an international leading standard system has been constructed; 285 national standards have been released, and 28 international standards have been formulated; nearly 80 industrial Internet platforms with industrial and regional influence have been cultivated. The results of promotion and application have been obvious, and the pilot demonstration projects have increased the production efficiency by 45% on average, shortened the product development cycle by 35% on average, and reduced the rate of defective products by 35% on average, and emerged new modes and new forms of discrete intelligent manufacturing, process intelligent manufacturing, network collaborative manufacturing, mass personalized customization, and remote operation and maintenance services, etc. However, compared with the requirements for high-quality development, the Industrial Internet is still in the process of being developed. However, compared with the requirements of high-quality development, the development of intelligent manufacturing still exists in the supply of poor adaptability, innovation capability is not strong, the depth and breadth of the application is not enough, the lack of professionals and other issues.

"The 14th- Five year Plan" and a long period of time in the future, to promote intelligent manufacturing, based on the essence of manufacturing, closely follow the characteristics of intelligence, process, equipment as the core, based on data, relying on manufacturing units, workshops, factories, supply chain and other carriers, to build a virtual-reality integration, knowledge-driven, dynamic optimization, safe and efficient, green and low-carbon intelligent manufacturing system, and promote the manufacturing industry to realize digital transformation, networked collaboration and intelligent transformation. By 2025, most of the manufacturing enterprises above the scale will realize digital networkization, and the key industries and backbone enterprises will initially apply intelligence; by 2035, the manufacturing enterprises above the scale will fully popularize digital networkization, and the key industries and backbone enterprises will basically realize intelligence.

Strengthen the leading role of scientific and technological support, promote interdisciplinary and cross-field integration and innovation, fight the battle of key core and system integration technologies, build a perfect innovation network, and continuously improve the effectiveness of innovation. Strengthen the key core technology research. Focusing on the whole manufacturing process such as design, production, management and service, breakthroughs in basic technologies such as design simulation, hybrid modeling and collaborative optimization, development and application of advanced process technologies such as additive manufacturing and ultra-precision machining, tackling generic technologies such as intellisense, man-machine collaboration and supply chain collaboration, and research and development of applicable technologies in the industrial field, such as artificial intelligence, 5G, big data, and edge computing, will be carried out. Accelerate the development of system integration technology. Facing equipment, units, workshops, factories and other manufacturing carriers, build data dictionaries and information models related to manufacturing equipment and production processes, and develop common data integration and cross-platform and cross-field business interconnection technologies for production processes. For the industrial chain supply chain, develop cross-enterprise multi-source information interaction and whole-chain co-optimization technology. For the whole manufacturing process, breakthroughs in intelligent manufacturing system planning and design, modeling and simulation, analysis and optimization technologies.

Promote the construction of new innovation networks. Focusing on key areas such as key processes, machine tools, digital twins, industrial intelligence, etc., support industry-leading enterprises to build a number of manufacturing innovation carriers in conjunction with colleges and universities, research institutes and upstream and downstream enterprises. Encourage R&D organizations to innovate development mechanisms, strengthen data sharing and platform construction, and carry out collaborative innovation. Promote the construction of industrialization promotion organizations and accelerate the transfer and transformation of innovative achievements. It will build a number of test and verification platforms and accelerate the popularization and application of intelligent manufacturing equipment and systems.

4. Conclusion

This paper summarizes the overview of domestic and foreign manufacturing development, the stages of development of manufacturing upgrading and its policy documents. On the whole, the advantages of foreign manufacturing transformation and upgrading lie in their strong technological innovation capability, strong brand influence, leading high-end manufacturing field and early implementation of intelligent manufacturing. However, there are also some shortcomings, such as higher labor costs, relatively weak adaptability to changes in external markets, and hollowing out of industries due to the external transfer of some traditional industries. The uniqueness of China's manufacturing transformation and upgrading lies in its rapid technological absorption and innovation capabilities, as well as strong government support at the policy level. In addition, the globalization of China's manufacturing industry has benefited from its strategic layout in supply chain integration, breaking through trade barriers, and accessing international resources. However, the transformation and upgrading of China's manufacturing industry also faces some challenges, such as technological innovation capacity needs to be further improved, there is still a gap between high-end manufacturing and developed countries, and some industries are facing the problem of overcapacity.

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