

Research on the Mechanism of Green Transformation of Manufacturing Industry Enabled by Digital Economy

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Abstract

With the rapid development of the digital economy and the accelerated penetration into the manufacturing field, promoting the green transformation of the manufacturing industry with the digital economy has become an important focus of building a modern industrial system. The digital economy with data as the core production factor enables the transformation and upgrading of the manufacturing industry, and its internal logical mechanism includes: first, digital technology can realize the dual energy saving of manufacturing enterprise management and technology, while effectively avoiding the distortion of resource allocation caused by policy deviation, and improving the overall energy utilization efficiency of the manufacturing industry. Second, digital technology enables manufacturing production and manufacturing, and the large-scale establishment of automated production lines has effectively improved the production efficiency of manufacturing enterprises. Third, the innovation effect of the digital economy encourages enterprises to innovate green processes, actively develop green production technologies, and reduce pollution emissions in the production process.

Keywords

Digital Economy; Manufacturing; Green Transformation.

1. Introduction

With the rapid development of the digital economy and the accelerated penetration into the manufacturing sector, the advantages of the digital economy in enhancing national competitiveness and global value chain are gradually highlighted, and promoting the green transformation and development of the manufacturing industry with the digital economy has become an important focus for building a modern industrial system. On April 9, 2020, the Central Committee of the Communist Party of China and The State Council issued the Opinions on Building a more perfect Market-oriented Allocation System and Mechanism of Factors, proposing to accelerate the cultivation of the data factor market. "Accelerate the development of the digital economy, promote the deep integration of the digital economy and the real economy, and promote the high-end, intelligent and green development of the manufacturing industry," the report of the 20th National Congress of the Communist Party of China proposed. The manufacturing industry is the foundation of building a modern industrial system, and it is also the focus of promoting the quality and efficiency of the real economy. At this stage, China has established a complete manufacturing industry chain in the world, ranking in the forefront of the world in terms of scale and category for many years. However, the development of China's manufacturing industry is also facing many challenges. On the one hand, China's manufacturing industry still has a certain gap with advanced countries in some core technologies and high-end equipment production and other fields, and the lack of independent innovation ability has led to some "stuck neck" problems. On the other hand, the "double carbon goal" has become a medium - and long-term constraint on the development of manufacturing industry, and some

manufacturing enterprises still follow the production mode of high input, high emissions and low added value of products, which is obviously contrary to the high-quality development of China's economy and the construction of ecological civilization, and it is urgent to achieve green transformation.

Promoting the green transformation of manufacturing and the green and low-carbon transformation and upgrading of traditional industries is the key. For some time, through green and low-carbon transformation and upgrading, China's traditional industries have improved in terms of technology and equipment, resource and energy utilization efficiency, and the emission intensity of major pollutants and carbon dioxide in key industries and areas has continued to decline. However, it should be noted that some manufacturing industries in Liaoning Province are still facing problems such as greater pressure for transformation and imperfect supporting systems for transformation. Therefore, it is necessary to accelerate the optimization and adjustment of traditional industrial product structure, energy use structure, raw material structure and process reengineering, and build a clean, efficient and low-carbon industrial energy consumption structure. At the same time, it is also necessary to comprehensively consider factors such as regional industrial base, resource endowment, and environmental carrying capacity, and promote the formation of a new pattern of cluster and differentiated green and low-carbon transformation of traditional industries. Under the requirements of reaching the peak of carbon and carbon neutrality, the current hard constraints faced by resources and the environment have also increased significantly, and promoting the green development of the manufacturing industry is of great significance for the economy to move towards a high-quality development stage and build a new development pattern.

2. Concept Definition and Related Theories

2.1. Concept of Digital Economy

Digital economy was first proposed by Don Tapscott in 1995, the early concept is often considered to be synonymous with the Internet economy or information economy, and with the continuous development of technology, the connotation of digital economy continues to expand, according to the definition of the G20 Digital Economy Development and Cooperation Initiative. Digital economy refers to "a series of economic activities that use digital knowledge and information as key production factors, modern information networks as an important carrier, and the effective use of information and communication technologies as an important driving force for improving efficiency and optimizing economic structure." According to the definition of the White Paper on China's Digital Economy, the digital economy is a more advanced economic stage after the agricultural economy and the industrial economy. Digital economy takes digital knowledge and information as the key production factors, digital technology innovation as the core driving force, modern information network as an important carrier, through the deep integration of digital technology and the real economy, constantly improve the digital and intelligent level of traditional industries, and accelerate the reconstruction of economic development and government governance model of a new economic form. Statistical Classification of Digital Economy and Its Core Industries (2021): Digital product manufacturing industry, digital product service industry, digital technology application industry, digital factor driving industry, digital efficiency improvement industry, etc.

2.2. Characteristics of Digital Economy

2.2.1. High Permeability

Through the integration of digital technology and the real economy, the digital economy shows its characteristics of high permeability, and becomes an important driving force to improve the

efficiency of resource allocation and promote economic growth. First, the digital economy promotes the organic integration of hardware and software. The boundaries of the use of next-generation information technologies such as big data, blockchain, AI technology, deep learning, cloud technology, and 5G communication are gradually blurring, hardware and software technologies are highly related, and the "Internet +" model is deeply integrated with many aspects of production and life, which promotes the growth of economic benefits while also promoting social equity and the improvement of people's livelihood. Second, the digital economy can accelerate the integration of different levels and sectors. The modern enterprise organization is more and more inclined to the horizontal and partial integration development, and the development of digital technology improves the process of this transformation. Finally, the interactive integration of public products and private products is realized. In the era of digital economy, the extensive establishment of digital platforms can unite a large number of enterprises and management institutions, breaking the boundary between public goods and private products.

2.2.2. High Additivity

The factors of production belong to the historical category of dynamic change, and the contents contained in them will also be different due to the change of economic form. Traditional factors of production mainly include capital, labor, land, etc., but their contribution to economic growth is getting closer to the bottleneck. With the continuous breakthroughs in digital technologies such as big data, blockchain, AI technology, deep learning, and cloud technology, the digital economy has emerged and become a new business form and new driving force for economic growth and structural optimization. In the form of digital economy, the status and role of data have undergone profound changes, continuously penetrating into various fields and departments of economic development, becoming a new factor of production alongside the traditional total factors of production, and playing an increasingly important role in the era of digital economy (CAI Yuezhou and Ma Wenjun, 2021). Data elements have become the main driving force for the development of the digital economy, which has also transformed the competition between countries and regions from traditional elements to data-related network infrastructure construction and digital talents, and has become the core factor determining core competitiveness. Digital elements have high value addition, play a positive role in promoting economic development, and promote economic efficiency is also very obvious.

2.2.3. High Portability

The development and maturity of the new generation of information technology has promoted the trend of industrial integration more and more obvious, and the continuous integration and symbiosis between industries have emerged some new industrial forms (Li Xiaohua, 2018). Because the new generation of information technology industry represented by 5G communication technology, deep learning, AI technology and big data has its own distinct advantages, not only information technology has significant spillover effect, but also has a broad space for development. Digital technology also helps to reduce energy consumption, and can provide a more obvious driving force for emerging economic forms. Promote the transformation of the existing economic development mode (Wang Stan and Wang Yi, 2015). Moreover, in the era of digital economy, digital technology itself has a strong driving force, and the deep integration with traditional industries can generate new products and new formats. Compared with traditional industries, the development and dissemination of a new generation of information technology greatly reduces the cost of technology dissemination and industrial structure innovation, and drives the rapid development of multiple industries and fields.

2.2.4. Innovative Integration

The new generation of information technology is represented by big data, cloud computing, deep learning, blockchain, and AI. The digital economy developed on the basis of this

technology has the advantages of being highly innovative and covering a wide range of areas. It is also becoming an important factor in optimizing the allocation of global factor resources, improving the world economic structure, and influencing the competition pattern of various countries. It promotes the systematic digital transformation of the economy and society from local to whole, stage to whole process. The development of digital economy has a comprehensive and profound impact on the world, China, economy and society, especially its profound impact on the mode of economic growth and economic structural adjustment. This new economic form is constantly and continuously expanding and enhancing this influence. Moreover, the digital economy also uses digital technology innovation to promote the transformation of production relations, providing innovative momentum for the transformation of various fields of economy and society.

2.3. Relevant Theoretical Research

2.3.1. Digital Transformation of Manufacturing Industry

Digitalization can promote the transformation of the manufacturing industry in multiple fields, multiple links and multiple ways, bring value creation to enterprises, and enable enterprises to achieve sustainable development. First, digital technology is the main driver of enterprise business model innovation. Business model is a mechanism for delivering the value of products and services to customers and obtaining returns. Its high degree of digital technology innovation can reshape the production chain and help enterprises grow rapidly. Second, digitalization changes enterprise product architecture. On the one hand, adding intelligent equipment such as data analysis and information processing to the product production of manufacturing enterprises can transform ordinary sales products into matter-intelligence integration products. On the other hand, value-added services and software are developed on the basis of existing products. Third, digitization helps manufacturing companies tap into the value of data. Through the collection and analysis of market and user information, the operation efficiency of enterprises can be optimized and the accuracy of decision-making can be guaranteed. Fourth, use the Internet to fully mobilize external resources to provide services for the enterprise itself. There are three main methods: manufacturing enterprises transform themselves into resource integrators, manufacturing enterprises transform into platform operators, and manufacturing enterprises establish themselves or use service carriers provided by third parties. Fifth, digital technology has a significant impact on the business process of manufacturing enterprises. Intelligent equipment can grasp the feedback information of enterprise operations in real time, minimize risks, reduce enterprise losses, and reduce operating costs.

2.3.2. Green Development of Manufacturing Industry

Green development refers to the process of enterprises adhering to the concept of green development, taking green innovation as the core, taking into account economic and environmental performance, and ultimately achieving a win-win situation between enterprises and ecology. At present, the domestic research on the green transformation of manufacturing industry can be roughly divided into micro and macro levels. From the macro level, it is mainly divided into three parts: First, through the construction of green evaluation system to explore the green transformation efficiency of manufacturing industry in different regions, and the impact of different regional characteristics on industrial green development. Second, through empirical research, it is proved that environmental regulation has an impact on the technological innovation of enterprises and then promotes the green development of enterprises. The third is to explore the promoting role of enterprise green development in narrowing the differences between different regions. From the micro level, it is also divided into three parts: First, based on the disclosure of CSR, green credit and other policies to explore the impact on the green transformation of enterprises. The second is to explore the common

characteristics of each subsector in the process of achieving green development. The third is to explore the path and strategy of enterprise green development.

2.3.3. Digitalization Enables Green Development

In the wave of digitalization, digital technology is the key point to connect manufacturing industry and friendly environment[1]. Digitization can effectively improve the efficiency of green innovation in cities and bring benefits to small and medium-sized cities. From the perspective of technology integration, digital level has an inverted U-shaped and linear relationship to enterprise green technology innovation. In addition, technological innovation plays an important role in pollution reduction. On the one hand, the energy saving effect, technological innovation in the premise of ensuring productivity, reduce the enterprise's resource investment, improve the efficiency of energy use. Technological innovation can promote the widespread use of clean energy, reduce or even eliminate pollution emissions, eliminate backward production technology and backward production capacity with high energy dependence, and guide the industry to develop in a cleaner and energy-saving direction. Although the existing studies have confirmed the role of digital transformation in promoting the green development of manufacturing industry from the theoretical level, there is a lack of practical research on the manufacturing enterprise level from the micro perspective. In particular, the heterogeneity factors of different flow segments in the Yellow River Basin are prominent, so enterprises should have their own criteria in digital path selection. Based on this, this paper starts with the multiple heterogeneity factors in the Yellow River Basin, and sorts out the multiple digital transformation high-end empowerment path and its internal logic for the manufacturing industry in the diverging section, which will help enterprises win the first-mover advantage, form a double spiral cycle system of digitalization and green, and provide theoretical guidance for the efficient green transformation of manufacturing enterprises in the basin.

3. The Internal Logic of Digital Economy Enabling the Green Transformation and Upgrading of Manufacturing Industry

The production process of manufacturing industry mainly includes two production factors: input factors and output factors. Input factors refer to the preparation before the start of production. According to the neoclassical growth theory, labor, capital and energy are the three core input factors of production, in which labor and capital input belong to renewable resources, and energy belongs to non-renewable resources. By putting in production factors and using related technologies and processes, enterprises can obtain corresponding output factors, including expected output and non-expected output. In this production process, the traditional manufacturing industry is facing the problems of low output, high pollution and high energy consumption due to backward technology and production process. In order to alleviate the pressure on the ecological environment and promote the construction of ecological civilization, manufacturing enterprises must further develop themselves to meet the current requirements, that is, reduce non-renewable energy input, reduce production waste pollution output, and improve energy utilization efficiency and expected output production efficiency[2]. The realization of this process requires the green transformation and upgrading of the manufacturing industry. Therefore, the essence of achieving green efficiency in manufacturing is to reduce the waste of non-renewable energy and resources in the input factors, while reducing the non-expected output in the output factors and increasing the expected output.

The digital economy with data as the core production factor not only naturally has a high green value, but also has external economic characteristics, and is an important driver to promote the green transformation and upgrading of the manufacturing industry. The digital economy enables the transformation and upgrading of the manufacturing industry, and its internal

logical mechanism includes: first, digital technology can realize the dual energy saving of manufacturing enterprise management and technology, while effectively avoiding the distortion of resource allocation caused by policy deviation, and improving the overall energy utilization efficiency of the manufacturing industry. Second, digital technology enables manufacturing production and manufacturing, and the large-scale establishment of automated production lines has effectively improved the production efficiency of manufacturing enterprises. Third, the innovation effect of the digital economy encourages enterprises to innovate green processes, actively develop green production technologies, and reduce pollution emissions in the production process.

3.1. Improve the Energy Utilization Efficiency of Manufacturing Industry through Management and Technology Energy Conservation

The manufacturing enterprises in the green transformation and upgrading stage intuitively show the improvement of the level of green transformation and upgrading. Therefore, the manufacturing enterprises will take a series of digital measures to promote the deep integration of digital technology and manufacturing technology, use digital technology to integrate production resources, detect changes in the external environment and improve the dynamic response ability of the market. In turn, the digital economy enables the process of smart manufacturing and green development. Specifically, as the development of the digital economy can bring about the improvement of the level of digital technology, and then produce the effect of technology iteration, the iteration of new technologies can significantly promote the improvement of manufacturing production mode, and play the multidimensional auxiliary role of new digital technologies such as 5G technology, artificial intelligence and industrial Internet in the green transformation and upgrading of manufacturing industry. Help enterprises build long-term competitive advantages.

First of all, based on the digital empowerment theory and resource-based view theory, from the perspective of resource empowerment, the improvement of enterprise digital technology transformation level can bring efficient connected information network and advanced digital design, improve enterprise resource integration ability, and integrate green innovation elements into a series of processes of enterprise production and operation. The greening of the production process and the efficiency of resource allocation can form a green development network organization with multi-party participation and interaction, so as to achieve real-time insight of resource information collection and environmental status monitoring, promote the deep integration of new digital technologies with manufacturing production processes and operation modes, and improve environmental governance performance while increasing output. Secondly, according to the theory of dynamic capability, under the background of digital economy, the internal and external environment of the development of manufacturing industry has undergone great changes, from "simple and stable" to "complex and dynamic"[3]. With the continuous increase of environmental dynamics, higher requirements are put forward for the market response ability of manufacturing enterprises. By improving the enterprise information integration and in-depth analysis ability, digital technology can achieve real-time market insight and enhance the dynamic response ability of the market, which is conducive to scientific decision-making, integrating advanced information technology on the basis of traditional production processes, promoting the transparency of manufacturing processes and the precision of service objectives, and accurately grasping the policy orientation and market demand based on big data prediction. Through digital means to cater to the development trend of sustainable development and green innovation, change the traditional inefficient development model, and provide guarantee for the realization of green transformation and upgrading.

3.2. Digital Technology Enables Manufacturers to Improve the Production Efficiency of Manufacturing Enterprises

The development of the manufacturing industry has experienced the evolution process from labor and capital manufacturing to intelligent manufacturing, which can be interpreted as the emergence and application of digital manufacturing is the result of the continuous development of the manufacturing industry to higher production capacity, higher efficiency, higher quality, lower cost and higher added value. Different stages of development have different enabling and driving effects. In intelligent manufacturing, the rise of digital economy has become the main driving force for quality change. Driven by digitalization, networking, platforming and demand upgrading, it shows the characteristics of precision manufacturing services and digitization of manufacturing process, such as the COSMOPLAT platform built by Haier Group and the interconnected intelligent data sharing system built by Qingdao Red Collar Group. The integration of digital technology into the whole process of manufacturing enterprise innovation provides the possibility of global value chain restructuring. For manufacturing enterprises in the stage of green transformation and upgrading, the effect of green transformation and upgrading is intuitively reflected in the improvement of the level of green transformation and upgrading. Therefore, manufacturing enterprises will take a series of digital measures to promote the deep integration of digital technology and manufacturing technology, use digital technology to integrate production resources, detect changes in the external environment and improve the dynamic response ability of the market. And then promote the digital economy to enable manufacturing enterprises to improve the production efficiency.

3.3. Digital Economy Encourages Enterprises to Innovate Green Processes to Reduce Pollution Emissions

Digital economy, as a new economic paradigm with digital knowledge and information as the key factors of production, has set off a new round of industrial reform. According to the endogenous growth theory, internal technological innovation is the key factor to promote technological progress and benefit improvement. With the integration and development of digital technology and manufacturing technology, the marginal cost of linkage between various departments of the process continues to decrease, the income of the manufacturing process increases geometrically, and the technology spillover effect is significant. Intelligent, big data, networking and other digital technologies are guided by resource conservation and comprehensive utilization and environmental protection, and provide digital design for enterprises' green process innovation[4]. As a new means of technological innovation, green process innovation is divided into two dimensions: clean production technology innovation and end management technology innovation. Cleaner production technology innovation is a preventive environmental management strategy, and the end treatment technology innovation is a beneficial supplement to the source prevention strategy. The driving role of digital technology transformation is to realize the optimal design of clean production technologies such as material selection, process design, technology upgrading and production process transformation. Through the intelligent and networked improvement of existing production processes, the use intensity of inputs such as raw materials and energy is effectively reduced, and more environmentally friendly production materials and design schemes are used. Thus reducing the pressure of the whole process on resources and environment.[5] The end treatment technology innovation focuses on the disposal of waste generated in the production process of enterprises, and integrates digital technology and end treatment technology to realize the innovation of pollutant treatment technology and the improvement of the efficiency of pollutant treatment equipment, so as to achieve a win-win situation of environmental performance and economic performance.

4. Conclusion

This paper expounds the concept and characteristics of digital economy and related theories on digital transformation of manufacturing industry, green development of manufacturing industry and green development of digital empowerment, and puts forward the transformation and upgrading of manufacturing industry enabled by digital economy. Its internal logic mechanism includes three aspects: First, digital technology can realize the dual energy saving of manufacturing enterprise management and technology, while effectively avoiding the distortion of resource allocation caused by policy deviation, and improving the energy utilization efficiency of manufacturing industry as a whole. Second, digital technology enables manufacturing production and manufacturing, and the large-scale establishment of automated production lines has effectively improved the production efficiency of manufacturing enterprises. Third, the innovation effect of the digital economy encourages enterprises to innovate green processes, actively develop green production technologies, and reduce pollution emissions in the production process.

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