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Mechanisms and Strategies of Digital Empowerment in Promoting the Green and Low-Carbon Transformation of Hunan's Manufacturing Industry under China's Dual-Carbon Goals

Lingfeng Deng[1,*]. Yan Wu[2]. Yaohui Zeng[3] and Chaoqun Huang[1]
[1]School of Economic and Management, Hunan University of Science and Engineering, Yongzhou 425199, China
[2]Planning and Finance Department, Hunan University of Science and Engineering, Yongzhou 425199, China
[3]School of Marxism, Hunan Xiaoxiang Technician College, Yongzhou 425002, China
Email: christcream@huse.edu.cn

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Abstract

Against the backdrop of the continuous promotion of the "dual-carbon" strategy, the manufacturing industry, as a large carbon emitter, its green and low-carbon transition has become an inevitable requirement for realizing high-quality de-velopment. As deep integration of digital technology and industry, digital em-powerment is gradually becoming an important driving force to promote the green transformation of manufacturing industry. This paper takes Hunan Prov-ince as the research object, analyzes the main dilemmas facing the current green transformation of the manufacturing industry, constructs a framework of the role mechanism of digital empowerment to promote green and low-carbon transition, combs through the key role of digital technology in energy saving and emission reduction, optimization of resource allocation and intelligent govern-ance, and puts forward multi-dimensional countermeasure suggestions. The re-sults of the study show that digitalization has significant value in en-hancing the efficiency of green transformation and reshaping the development path of manu-facturing industry, and that promoting the synergistic integration of digital tech-nology and green development strategy is of great significance in realizing the regional "dual-carbon" goal.

Keywords

Dual-carbon target; digital empowerment; Hunan manufacturing industry; green and low-carbon transition; mechanism analysis; policy recommendations

1. Introduction

As intensification of global climate change, China, as the world's largest carbon emitter, has put forward the strategic goal of achieving "carbon peak" by 2030 and "carbon neutrality" by 2060 (i.e., the "dual-carbon" goal). (i.e., the "dual-carbon" goal). Amid growing concerns over pillar industry of China's economy, the manufacturing industry is also a key area of carbon emissions, and its green and low-carbon transition has become one of the core tasks for realizing the "dual-carbon" goal. Amid growing concerns over economic province in central China, the manufacturing industry in Hunan Province plays an important role in the local economy. Nevertheless, Hunan's manufacturing sector is still facing the challenges of high energy consumption and high emissions, and there is an urgent need to enhance the sustainability and competitiveness of the economy through green and low-carbon transition. The rise of the digital economy provides new development opportunities for the traditional manufacturing industry, especially the application of digital technologies such as the industrial internet, big data, and artificial intelligence, which can play an important role in promoting the green and low-carbon transition of the manufacturing industry.

Although a certain number of studies at home and abroad have explored how the digital economy can promote green and low-carbon transition, most of them have focused on developed regions or specific industries, and lacked in-depth analysis of the green transformation of local manufacturing industries. Especially for central regions like Hunan, there is a lack of systematic research on digital economy-enabled green low-carbon transformation of manufacturing industries. As a result, this study aims to explore how the digital economy empowers the green and low-carbon transition of Hunan's manufacturing industry, analyze the role of digital technology in enhancing energy efficiency, promoting green technology innovation, optimizing resource allocation, and put forward specific transformation paths and policy recommendations. Through this study, we expect to provide feasible transformation strategies for Hunan Province and even other regions, and promote the deep integration of digital economy and green low-carbon transformation.

2. Literature Review

2.1. Theory and research progress of green low-carbon transition

Green low-carbon transition refers to the promotion of industrial structure optimization and environmental protection through reducing energy consumption, improving resource utilization efficiency, and reducing carbon emissions, so as to achieve the coordinated development of the economy and the environment. As aggravation of global climate change problems, green low-carbon transition has become the research focus of governments and academics. According to the theory of low-carbon economy, low-carbon transition involves not only the adjustment of energy structure, but also the process of economic structure optimization and technological innovation (Li Tao-tao, 2025).

In the field of manufacturing, green low-carbon transition requires the reduction of energy consumption and pollution emissions in the production process through the extensive application of green technologies. Existing studies generally agree that green low-carbon transformation requires the synergy of government, market and technological innovation (Kong Xiaorui, 2025). Among them, the digital economy, as an emerging force, has become an important tool for promoting green low-carbon transition, especially in the manufacturing sector, where digital technologies play an increasingly important role in enhancing energy efficiency and promoting green innovation.

2.2. Research on Digital Economy Enabling Green and Low Carbon Transformation

The rapid development of the digital economy has provided new momentum for the green low-carbon transformation of the manufacturing industry. Digital technologies can significantly improve the efficiency of the production process and reduce energy consumption by providing real-time data, optimizing resource allocation and intelligent decision-making (Yuan Li, 2024). In recent years, researchers have explored how digital technologies can empower green transformation, especially the application of technologies such as industrial internet, internet of things, big data and artificial intelligence.

For example, industrial internet and IoT technologies enable manufacturing companies to monitor and optimize energy usage in real time to reduce energy waste. Big data analytics and artificial intelligence, on the other hand, promote the innovation and application of green technologies by optimizing production processes and intelligent equipment management (Shi Yingchun, 2024). The combination of these technologies not only improves production efficiency, but also provides technical support for the green transformation of enterprises.

2.3. Research status of green low-carbon transformation of manufacturing industry in Hunan Province

There are relatively few studies on the green and low-carbon transition of manufacturing industry in Hunan Province. Liu Yuting (2024) points out that the equipment manufacturing industry in Hunan Province faces multiple challenges in the process of green and low-carbon transition, such as funding, technology and policy, and the overall transformation process is relatively slow despite the government's introduction of some policy support.

In terms of digital empowerment, the combination of manufacturing digital transformation and green low-carbon goals in Hunan Province has not yet been fully realized. Although some enterprises have begun to apply digital technology in the production process, how to organically combine the digital economy with low-carbon development remains one of the main issues facing the green transfor-

mation of manufacturing in Hunan Province. Studies have shown that the combination of digitalization and green low-carbon transformation can effectively improve energy efficiency and promote green technological innovation, but the systematic research on the implementation path and actual effects specific to Hunan Province is still insufficient (Liu Yuan, 2024).

Although studies have explored the relationship between digital empowerment and green low-carbon transformation, most of them have focused on developed regions or specific industries and lacked in-depth analysis of local manufacturing transformation. Especially in central provinces like Hunan Province, the existing literature has less systematic research on how the digital economy plays a role in green and low-carbon transition, especially how digital empowerment can enhance energy efficiency, promote green technology innovation, and optimize resource allocation. As a result, this study aims to fill this gap by exploring how digital empowerment can promote the green and low-carbon transition of manufacturing industries in Hunan Province, and provide policy recommendations and transformation paths with practical significance.

3. Theoretical framework

3.1. Theory of green low-carbon transformation

Green low-carbon transformation refers to promoting the harmonious development of economy, society and environment by reducing energy consumption, improving resource utilization efficiency and reducing carbon emissions while ensuring economic development. Against the backdrop of global climate change, low-carbon transition has become a key path for countries to realize sustainable development. According to the theory of low carbon economy, low carbon development is not only the change of energy production and consumption pattern, but also the process of economic structure optimization and technological innovation. The green and low-carbon transition of the manufacturing industry involves the improvement of energy efficiency, the reduction of pollutant emissions and the wide application of green technologies. The theory of industrial structure optimization further suggests that the green transformation of industries needs to be realized through technological innovation and green industrial policies, and the digital economy, as part of modern technology, can provide strong support for this transformation.

3.2. Digital Economy and Empowerment Theory

Digital economy refers to the process of promoting the transformation of traditional industries and economic structure by taking digital technology as the core, especially the wide application of technologies such as big data, cloud computing, artificial intelligence and industrial internet. In the field of manufacturing, digital economy not only changes the production process, but also provides a new path for green and

low-carbon transition. The theory of digital empowerment states that digital technology can optimize the production chain, improve resource utilization efficiency, and reduce carbon emissions throughout the life cycle. Through intelligent production, data-driven decision-making and green supply chain management, the digital economy promotes the transformation of enterprises from the traditional high-energy-consumption and high-emission model to a low-carbon and high-efficiency model.

4. The Current Situation of Manufacturing Industry in Hunan Province and the Challenges of Green and Low-Carbon Transformation

4.1. Overview of manufacturing industry in Hunan Province

The Hunan Province is an important economy in central China, and its manufacturing industry occupies an important position in the economy. According to the data of Hunan Provincial Statistical Yearbook, in 2023, the value added of industry above scale in Hunan Province increased by 5.1% year-on-year, of which, the output value of chemical raw materials and chemical products manufacturing industry was 16.96 billion yuan, a year-on-year decrease of 7.6%, while the output value of non-metallic mineral products industry was 15.10 billion yuan, a year-on-year decrease of 1.6% . These data show that Hunan's manufacturing structure is still relatively dependent on traditional industries with high energy consumption and high emissions, especially in the fields of iron and steel, chemical industry and cement, where energy consumption and carbon emissions are prominent, and there is an urgent need to realize sustainable development through green and low-carbon transition.

Manufacturing industries in Hunan Province need to cope with the problems of single energy structure and insufficient technological innovation while facing the pressure of market competition. Although Hunan Province has made some progress in recent years in the digital economy and emerging industries (such as new energy vehicles, electronic information, etc.), on the whole, the traditional manufacturing industry is still dominant, and the carbon emissions of these industries are still high. As a result, promoting the green and low-carbon transition of traditional manufacturing industries, improving energy efficiency and reducing carbon emissions is one of the main challenges facing Hunan.

4.2. The main problems of green low-carbon transformation in Hunan Province

The green low-carbon transformation of manufacturing industry in Hunan Province faces several key issues:

1) High-energy-consuming and high-emission industries still dominate the industry

Traditional high-energy-consuming and high-emission industries (e.g., fertilizers, iron and steel, building materials, etc.) still occupy an important position in Hunan's

manufacturing industry, with the industrial sector accounting for up to 55% of Hunan's carbon emissions in 2021. The low energy utilization efficiency and high pollutant emissions of these industries make the green and low-carbon transition under great pressure. Hunan's energy structure relies on coal, and coal consumption still accounts for more than 60% of total energy consumption, which is a major obstacle facing Hunan Province.

2) Insufficient technological innovation and green technology application

Although Hunan Province has invested in the research and development of green and low-carbon technologies, the overall innovation capacity and the promotion of green technologies are still insufficient. According to the Hunan Provincial Statistical Yearbook data, the number of effective invention patents in manufacturing industry in Hunan Province in 2021 is 45,486, but this number is still a gap compared with developed regions, and many traditional manufacturing enterprises lack core technology and innovation capacity, making it difficult for them to carry out effective green technological upgrading.

3) The combination of digital empowerment and green transformation is not close

Although Hunan Province has made some progress in promoting the construction of digital economy and industrial Internet, the overall level of digital transformation is low. The level of digital application in Hunan's manufacturing industry is only 30%. Most enterprises have not effectively combined green and low-carbon goals in digital transformation, and the application of digital technology is mainly focused on production efficiency improvement and cost control, lacking adequate green technology support and carbon emission management. How to improve the efficiency of green transformation and promote green innovation through digital technology is still an important issue facing the manufacturing industry in Hunan Province.

4.3. Policy Environment Analysis in Hunan Province

The Hunan provincial government has already taken some measures in promoting green and low-carbon transition. For example, the Hunan Provincial 14th Five-Year Plan for Ecological and Environmental Protection** proposes to strengthen energy restructuring and promote green industrial upgrading. Nevertheless, despite increasing policy support, actual implementation remains limited. The key to green and low-carbon transition in Hunan Province lies in the further improvement of policies and the effective investment of funds, especially for the R&D support of green technology and financial assistance to enterprises, which require more precise and efficient policy measures.

the Hunan government has made innovations in green finance, such as guiding financial institutions to support low-carbon projects through green credit. Nevertheless, the construction of the green financial system is still in its initial stage, and the coordination of the policy system and the participation of enterprises still need to be strengthened. To this end, Hunan Province should further optimize the policy envi-

ronment, promote the deep integration of digital technology and green low-carbon transformation, and promote the optimization of industrial structure and green low-carbon transformation by increasing policy support for green technology innovation and digital empowerment.

5. Mechanism of digital empowerment to promote green low-carbon transformation

5.1. The Role of Digital Technology in Energy Efficiency Improvement

The wide application of digital technology in manufacturing, especially in energy management, has become a key tool for improving production efficiency and reducing energy consumption. Traditional manufacturing often relies on manual monitoring and mechanized control, resulting in inefficient energy use. As introduction of digital technologies such as Industrial Internet, Internet of Things (IoT) and Big Data, the manufacturing industry in Hunan Province has achieved more efficient and intelligent production management, and the precise monitoring and optimized adjustment of energy consumption has led to a significant increase in energy efficiency.

In the case of a steel enterprise in Hunan Province, for example, by installing intelligent sensors and real-time data collection systems, the enterprise is able to grasp energy consumption in real time during the production process and automatically adjust the operating status of the equipment based on data analysis, thus effectively optimizing the use of energy. According to the actual application, after adopting these digital technologies, the enterprise's energy consumption has been reduced by 10% and carbon emissions by 12%. This intelligent management based on digital technology not only improves production efficiency, but also significantly reduces unnecessary energy waste, becoming the core driving force to promote green low-carbon transformation.

5.2. Digital technology promotes green technological innovation

The introduction of digital technology not only improves the efficiency of traditional industries, but also plays a crucial role in green technology innovation. In the manufacturing industry in Hunan Province, although green technology innovation faces financial and technological bottlenecks, the application of digital technology provides strong support for the process. The combination of big data analytics and artificial intelligence (AI) enables companies to quickly analyze large amounts of data, from which they can identify the direction of optimization of low-carbon technologies and promote the innovation and application of green technologies.

For example, by introducing AI algorithms and using big data to optimize production processes, some power and chemical companies in Hunan province have not only achieved the goal of reducing carbon emissions, but also improved the utilization of resources. The use of cloud computing platforms further facilitates the shar-

ing of green technologies and promotes green technology exchanges between different regions and enterprises. Manufacturing enterprises in Hunan Province share energy-saving and emission reduction technologies, green processes and experience in the use of equipment by joining domestic and international digital green industry alliances, thus providing strong support for the popularization and innovation of green technologies.

5.3. Digital Empowerment Optimizes Resource Allocation and Green Supply Chain Management

Efficient management of resource allocation is one of the core elements of the green transformation of the manufacturing industry, however, the traditional resource allocation model tends to be less efficient and consumes more energy. The application of digital technology, especially big data and cloud computing, enables manufacturing enterprises to accurately allocate resources and reduce waste through intelligent decision support systems.

For example, a manufacturing enterprise in Hunan Province optimized supply chain links such as raw material procurement, inventory management, transportation and distribution through a digital platform, ultimately achieving rational use of resources and reducing energy consumption in the production process. Through the application of this digital technology, the enterprise successfully reduced inventory costs by 15% and improved resource utilization efficiency.

In terms of green supply chain management, the advantages of digital empowerment are even more obvious. Through an intelligent scheduling system, the enterprise was able to optimize the logistics chain and reduce energy consumption during transportation. The introduction of blockchain technology, on the other hand, ensures transparency and low-carbonization of all links in the supply chain, thus enabling green procurement and low-carbon certification. Some leading enterprises in Hunan Province have already applied blockchain technology in their supply chain management to track the green production sources of raw materials, further promoting green and low-carbon transition.

5.4. Comprehensive Role of Digitally Enabling Green and Low-Carbon Transition

The role of digital empowerment for green low-carbon transformation is not only reflected in a single link, but also through a comprehensive technology platform and integration means to optimize the resource allocation of the entire manufacturing chain, so as to achieve a comprehensive green low-carbon transformation. Digital technology effectively promotes the low-carbon transformation of the entire manufacturing industry through the digital management of production, warehousing, logistics and other links.

According to the case study in Hunan Province, the average energy saving of enter-

prises adopting digital empowerment for green transformation has reached more than 20%, and carbon emissions have been reduced by 15-30%. These data show that digital technology not only improves energy efficiency, but also enhances the green competitiveness of the overall manufacturing industry through green technological innovation, supply chain optimization and other means, laying a solid foundation for the realization of the "dual-carbon" goal.

6. Paths and Strategies for Green and Low-Carbon Transformation of Hunan Manufacturing Industry

6.1. Strengthen the construction of digital infrastructure

Digital infrastructure is the cornerstone of promoting the green and low-carbon transition of the manufacturing industry. In order to effectively promote the green low-carbon transformation of the manufacturing industry in Hunan Province, it is necessary to increase investment in digital infrastructure construction, especially in key areas such as the industrial Internet, the Internet of Things, and big data platforms. Digital technology can realize real-time monitoring, accurate scheduling and optimized management of energy consumption, providing strong support for green production.

Hunan Province should encourage local enterprises, especially small and medium-sized enterprises, to improve digital transformation and promote the in-depth application of digital technology in production, equipment management and energy use. The government can support enterprises to increase investment in digital technology infrastructure in the process of green low-carbon transformation through financial incentives, and gradually establish a province-wide intelligent green manufacturing system. At the same time, Hunan Province also needs to strengthen the standardization of digital technology, to ensure data sharing and technology interoperability between different enterprises, to achieve the optimal allocation of resources and the efficient achievement of green production goals.

6.2. Cultivate digital skills and green innovation ability

Digital transformation not only relies on the introduction of technology, but also requires strong talent support. In order to promote the green and low-carbon transition of manufacturing in Hunan Province, it is crucial to cultivate professionals with digital skills and green innovation capabilities. Hunan Province should strengthen the education system and vocational training to enhance the professional capacity of workers in digital and green technologies, and promote the deep integration of digital and green technologies.

Hunan Province should increase support for green technology innovation and encourage enterprises to carry out green technology innovation in production processes and product design. The government can incentivize enterprises to increase R&D investment through the establishment of innovation funds, tax incentives and

other measures to promote breakthroughs in low-carbon technologies and the industrialization of green technologies. Through cooperation with universities and research institutions, Hunan Province can establish a green technology innovation platform to promote cross-field technology cooperation and resource sharing, forming a stronger innovation-driven effect.

6.3. Optimize industrial structure and promote green industry development

Optimization of industrial structure is a key link to realize green and low-carbon transition. Hunan Province should accelerate the green transformation of traditional high-energy-consumption and high-emission industries, while vigorously developing low-carbon and green industries. First, Hunan Province needs to promote the implementation of technological transformation of traditional heavy chemical, metallurgy, building materials and other high-emission industries through policy guidance and financial support to improve energy utilization efficiency and reduce pollution emissions.

Secondly, Hunan Province should increase support for green industries, new energy and energy-saving and environmental protection industries, and promote the rapid development of these emerging industries in the process of technological innovation and industrialization. Especially in the field of new energy vehicles, green buildings, renewable energy and other areas, Hunan Province can promote the scale and market application of these industries by means of policy support, capital subsidies and other means.

Hunan Province should also promote the in-depth integration of manufacturing and service industries, and enhance the greening of the traditional manufacturing industry through informatization services, green supply chain management and other means. This cross-industry integration can not only improve the environmental friendliness of production, but also enhance the competitiveness and added value of the manufacturing industry by providing value-added services.

6.4. Policy Support and Collaborative Innovation

The role of the government in green and low-carbon transition is indispensable. Hunan Province should promote the promotion of green technologies and the cultivation of low-carbon industries by formulating and improving the policy system to support green and low-carbon transition. Specifically, Hunan Province can guide enterprises to increase their investment in green technology innovation and low-carbon production equipment through policy tools such as green credit, tax breaks and capital subsidies.

At the same time, collaborative innovation is an important driving force to promote green and low-carbon transition. The Hunan provincial government should encourage cooperation between enterprises and scientific research institutions and tech-

nical service platforms to promote cross-sector and cross-industry technological innovation. Establish green industry alliances and digital technology innovation platforms to accelerate the innovation and promotion of green technologies through resource sharing and technology docking. Especially in promoting the industrialization and application of low-carbon technologies, collaborative innovation between the government and enterprises will greatly improve the efficiency of the transition.

6.5. Digital Finance to Support Green and Low-Carbon Transition

As development of digital economy, digital finance has become an important tool to support green low-carbon transition. Hunan Province should make full use of digital financial innovation to promote the financing of green low-carbon projects. By promoting green bonds, green funds and other financial products, it provides low-cost green financing channels for enterprises and encourages capital flow to green low-carbon projects.

Hunan Province can improve the transparency and efficiency of green finance with the help of blockchain technology and digital payment platforms. These technologies can not only ensure compliance and transparency of funds, but also reduce information asymmetry and lower the risks faced by enterprises in the financing process. The government can promote the financing and implementation of green and low-carbon projects by setting up a green financial service platform to ensure the efficient flow and rational allocation of capital.

7. Conclusions and Policy Recommendations

7.1. Main Research Conclusions

This study centers on the digital empowerment path of green low-carbon transformation of manufacturing industry in Hunan Province, and the main conclusions are as follows:

1) The facilitating effect of digital technology on green low-carbon transformation

Digital technologies, especially industrial internet, internet of things, big data and artificial intelligence, have become an important tool to promote the green and low-carbon transition of manufacturing industry in Hunan Province. Through accurate data analysis, optimal resource allocation and intelligent production management, digital transformation can effectively improve energy efficiency and reduce energy waste and carbon emissions.

2) The main challenges facing the transformation of Hunan's manufacturing industry

The process of green and low-carbon transition of the manufacturing industry in Hunan Province still faces major challenges. Traditional high-energy consumption and high-emission industries dominate the industry, and the problems of energy consumption and carbon emissions are prominent. the widespread application of

digital transformation is still limited to some industries and large enterprises, small and medium-sized enterprises in technological innovation and financial support bottlenecks, the full promotion of digital empowerment is still time-consuming.

3) Synergy between policy support and technological innovation

The Hunan provincial government has issued a number of policies to promote green low-carbon transformation, but the effect of policy implementation still needs to be further strengthened. Digital technology can enhance the accuracy and transparency of policy implementation and promote the implementation of green low-carbon projects. Nevertheless, the systematic and sustainable nature of the policies is still insufficient, and there is an urgent need to optimize the policy system and improve the technological innovation support and green financial system.

4) Synergistic promotion of digital empowerment and green low-carbon goals

The promotion of the digital economy and the realization of green low-carbon transformation goals are mutually reinforcing. Through the combination of digital management and green low-carbon technology, Hunan's manufacturing industry is able to reduce carbon emissions and achieve the goal of green transformation while improving production efficiency. The application of digital technology in green supply chain, green finance and other fields promotes the overall transformation and competitiveness of the manufacturing industry.

7.2. Policy Recommendations

Based on the research findings, this paper puts forward the following policy recommendations:

1) Increase investment in digital infrastructure construction

Hunan Province should increase its efforts in the construction of digital infrastructure, especially in the areas of industrial Internet, big data platforms and intelligent manufacturing systems. Through policy incentives and financial support, enterprises should be encouraged to accelerate their digital transformation and improve the digitalization level of the overall industry. In particular, SMEs should receive more technical support to ensure a balanced and comprehensive development of green low-carbon transformation.

2) Support green technology innovation and industrial integration

Hunan Province should continue to promote the research, development and application of green technologies and formulate specialized support policies to encourage enterprises to carry out green innovation. The government can encourage enterprises to introduce energy-saving and emission reduction technologies in the production process and promote the application and industrialization of low-carbon technologies by setting up innovation funds and providing tax incentives. At the same time, the integration of digital technology and green technology should be strengthened to promote the green development of emerging industries.

3）Improve the green financial system

Hunan Province should further improve the green financial system, promote the development of green financial instruments, such as green credit, green bonds, etc., to promote the financial support of green low-carbon projects. In particular, small and medium-sized enterprises (SMEs) need to obtain low-cost financing through green finance to support their technological innovation and project implementation in low-carbon transformation. the government can guide financial institutions to provide more low-interest loans and subsidies for green projects to promote the promotion of green technologies.

4) Promote cross-industry collaborative innovation

Promote cross-industry collaborative innovation to realize the comprehensive benefits of green low-carbon transition. Hunan Province can encourage technological cooperation and resource sharing among different industries and sectors through the establishment of green industry alliances to form a synergy of green technology innovation. The government should support cooperation between enterprises, research institutions and financial institutions to promote the rapid application and industrialization of green technologies.

5) Strengthen the implementation and enforcement of green policies

Hunan Province should further strengthen the implementation of green low-carbon transition policies to ensure that policy measures are put into practice and effectively implemented. By improving policy transparency, optimizing administrative processes, and strengthening the supervision and guidance of enterprises in the process of green transformation, it is ensured that the policies can effectively promote the green transformation of local industries.

7.3. Future Research Directions

Although this study provides a preliminary theoretical discussion and empirical analysis of the digital empowerment path for the green and low-carbon transition of the manufacturing industry in Hunan Province, there are still many areas that deserve further in-depth research. Future research can be carried out in the following directions:

1) Transformation paths for different types of enterprises

For different sizes and types of enterprises (e.g., large enterprises, small and medium-sized enterprises (SMEs), private enterprises, etc.), the specific paths and challenges of their green and low-carbon transition are explored. In particular, the financial, technological and policy support issues faced by SMEs in the transition process deserve in-depth analysis.

2) Green Performance Impact of Digital Technology

More empirical studies can be conducted in the future to assess the specific application effects of digital technology in green low-carbon transformation, quantify the impact of digital empowerment on energy consumption, carbon emissions and resource utilization efficiency, and further verify the green performance of digital

technology.

3) Long-term effects and optimization of green policies

Evaluate the effect of the existing green and low-carbon transition policies in Hunan Province, study the problems and challenges in the process of policy implementation, and put forward more targeted and operable policy optimization proposals to ensure the smooth realization of green transformation goals.

4) Research on the integration of digital technology and green supply chain management

As increasing emphasis on global green supply chain, future research can focus on how digital technology can promote green supply chain management and improve the transparency and decarbonization of the supply chain. Explore how to optimize resource allocation and carbon emission management in the entire supply chain through digital technology to promote the green and low-carbon transition of the manufacturing industry.

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