

Digital Economy Challenges and Strategies for Transforming and Upgrading Jilin Manufacturing Enterprises

Jia Kai^{1*}, Mohamad Nasir Saludin² & Muhammad Omar³

¹ Kuala Lumpur University of Science and Technology, Business College, 43000 Kajang, Selangor Darul Ehsan, Malaysia

² Faculty of Multimedia, Enforcement & Technology, Universiti Geomatika Malaysia, 54200 Kuala Lumpur, Malaysia

³ Faculty of Business and Accountancy, Universiti Poly-Tech Malaysia (UPTM), 56100 Cheras, Kuala Lumpur, Malaysia

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ABSTRACT

Against the backdrop of China's accelerating digital economy and the urgent need to revitalize traditional industrial bases, promoting the digital transformation of manufacturing enterprises is essential for high-quality regional economic growth. As a traditional manufacturing hub with a strong industrial foundation but lagging digital integration, Jilin Province stands at a pivotal juncture of significant challenges and strategic opportunities. This study systematically examines the main constraints hindering this evolution, identifying key gaps such as insufficient digital infrastructure, limited technology adoption, a shortage of specialized digital talent, weak innovation capacity, and poor coordination between government policy and enterprise implementation. Grounded in a theoretical framework integrating digital economy, industrial upgrading, and regional development theories, the research uses a mixed-methods approach—combining policy analysis, enterprise surveys, and in-depth case studies. To address these challenges, the study proposes targeted strategies to strengthen digital infrastructure, build enterprise-level digital capabilities, and cultivate a composite talent pool of industrial and digital experts. It also emphasizes strengthening innovation ecosystems and refining policy support and governance mechanisms. Ultimately, these findings offer practical, actionable policy implications for local decision-makers in Jilin, while providing a strategic reference for other traditional industrial regions seeking a successful, digitally driven manufacturing transformation in an increasingly competitive global landscape.

Keywords: Digital Economy, Manufacturing Transformation and Upgrading, Digital Transformation, Regional Industrial Development, Jilin Province

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1. INTRODUCTION

The digital economy, driven by new-generation information technologies such as big data, cloud computing, artificial intelligence, and the industrial Internet, has become a core engine of global economic growth. In China, the digital economy has been elevated to a national strategic level, playing a key role in promoting industrial transformation and high-quality development. According to official statistics, China's digital economy has expanded rapidly since 2020, with industrial digitization accounting for an increasing share of economic output (National Bureau of Statistics of China, 2023).

Jilin Province, as an important manufacturing base in Northeast China, has long relied on traditional industries such as automobile manufacturing, petrochemicals, and equipment manufacturing. However, under the combined pressures of slowing economic growth, intensified interregional competition, and technological change, the traditional development model of manufacturing enterprises in Jilin Province has become increasingly unsustainable. Promoting manufacturing transformation and upgrading through the digital economy has therefore become an urgent task for enterprises and policymakers alike.

"Made in China 2025" clearly sets out nine strategic tasks and priorities, emphasizing the enhancement of the country's manufacturing innovation capabilities and the deep integration of industrialization and informatization. This provides significant guidance for the comprehensive promotion of intelligent manufacturing and is highly significant for improving the internationalization level of the manufacturing industry. Currently, the digital economy has become an inevitable trend, and intelligent, networked, and data-driven production and operation methods have become new highlights of economic development. In the digital economy, digital resources have become key drivers of efficient production for manufacturing enterprises. Applying digital resources optimizes resource allocation across traditional manufacturing operations, product production, and technological research and development, creating new opportunities to transform and upgrade traditional manufacturing enterprises. To improve manufacturing quality and efficiency, enterprises must rely on digital technology to drive innovation, achieve intelligent manufacturing by strengthening R&D and infrastructure, and enhance product performance and brand value. Therefore, against the backdrop of the digital economy, the digital transformation and upgrading of manufacturing enterprises have become an urgent issue to study.

2. LITERATURE REVIEW

2.1. Digital Economy and Manufacturing Transformation

Existing studies widely agree that the digital economy enhances manufacturing competitiveness by improving production efficiency, reducing transaction costs, and fostering new business models. Digital technologies enable real-time data collection and intelligent decision-making, thereby reshaping production processes and organizational structures (OECD, 2020). Empirical research in China also confirms that industrial digitization significantly promotes productivity growth and technological upgrading in manufacturing enterprises (Zhang & Chen, 2021).

2.2. The connotation of digital transformation

The definition of enterprise digital transformation is a dynamic process that scholars continually adjust and refine in theory and practice. As enterprise digital transformation advances and is implemented, this concept will continue to evolve and be refined. Digital transformation refers to integrating digital technologies such as big data, cloud computing, artificial intelligence, and the industrial internet into enterprises' production, management, and governance processes (Vial, 2021). Digital transformation was first proposed by IBM, referring to the use of various digital technologies by enterprises, through processing methods such as big data and cloud computing, to integrate data in the enterprise's production and operation processes and form valuable digital assets. It can be seen as a process of creating commercial value, emphasizing the application of digital technologies to reshape customer value and enhance enterprise-customer interaction (Su et al., 2023). As understanding of digital transformation deepens, more scholars recognize that digital transformation is not only the use and iteration of digital technologies by enterprises, but also includes the digitalization of business interactions, value exchanges, and other business models (Chi et al., 2020).

Data plays a crucial role in digital transformation. By applying technologies and methods such as data capture, digital analysis, and algorithm processing, it promotes comprehensive innovation within enterprises and cultivates a data chain for data collection, analysis, and problem-solving. As data accumulates and circulates, the enabling effect of digital transformation becomes evident, steadily enhancing enterprise development (Chen et al., 2020). Digital technology-driven changes in working methods, organizational structures, and even business models aim to optimize, innovate, and reconstruct enterprises' value systems (Mancuso et al., 2023). Although digital transformation brings numerous benefits to enterprises, it can also lead to a blind pursuit of performance gains at the expense of environmental protection and social responsibility (Shi et al., 2023). A key aspect of digital transformation is effectively applying relevant elements in

enterprise operations and management, including not only technological adoption but also fundamental reorganization of enterprise strategy, business models, operational processes, and organizational structures (Li, 2024).

Many scholars have defined digital transformation from different perspectives. This article holds that digital transformation is a crucial corporate strategy. By leveraging digital technologies and tools, enterprises reshape or optimize their entire operational processes to maintain a competitive edge and enhance their development quality within the industry. This goal is not achieved overnight but through continuous exploration and adaptation.

2.3. The background of the transformation of manufacturing enterprises in Jilin Province

2.3.1. National level

In China, digital transformation has become a core component of the national development strategy. Government initiatives such as "Digital China", "New Infrastructure Construction", and "Action Plan for the Development of Industrial Internet" emphasize the integration of digital technology with the real economy to promote high-quality growth (Wu et al., 2024). Empirical research indicates that digital transformation significantly improves enterprise performance by optimizing production efficiency, enhancing innovation outcomes, and strengthening market competitiveness (Wang et al., 2024).

2.3.2. At the provincial level of Jilin

Jilin Province is located in northeastern China and is a representative old industrial base in the country. Historically, heavy industry, automobile manufacturing, petrochemicals, and equipment manufacturing industries have all been concentrated there (Ban et al., 2025). According to the "Statistical Bulletin of the National Economic and Social Development of Jilin Province in 2025", the province's GDP in 2025 was 1,497.388 billion yuan, with a year-on-year growth of 5.0%, ranking 26th among all provinces and municipalities in China. In traditional industrial bases like Jilin Province, enterprises face problems such as rigid structures, talent drain, and outdated management systems (Zhu, 2023). Therefore, understanding how digital transformation affects enterprise performance and under what conditions it can succeed is of significant theoretical and practical importance.



Figure 1. Northeast China on the Map of China

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2.4. Industrial Upgrading Theory

Industrial upgrading theory emphasizes the transition from low value-added activities to high value-added ones through process, product, functional, and value-chain upgrading. Technological innovation and institutional support drive this process (UNIDO, 2022). In the digital economy, data has become a new factor of production, accelerating the reconfiguration of manufacturing value chains.

2.5. Regional Perspective

Recent studies highlight that regional differences significantly affect digital transformation outcomes. Compared with coastal regions, traditional industrial bases such as Northeast China often face constraints related to talent shortages, rigid institutional systems, and weak innovation ecosystems (Liu & Wang, 2023). However, region-specific research on Jilin Province remains relatively limited.

3. CURRENT STATUS OF MANUFACTURING AND DIGITAL ECONOMY IN JILIN PROVINCE

3.1. Manufacturing Industry Structure

Jilin Province's manufacturing sector is characterized by a high concentration of traditional heavy industries, particularly automobile manufacturing and petrochemicals. Large state-owned and legacy enterprises dominate the industrial landscape, while small and medium-sized enterprises (SMEs) generally exhibit low technological intensity and limited innovation capacity.

3.2. Development of the Digital Economy

In recent years, Jilin Province has made progress in building digital infrastructure, including broadband networks and data centers. However, compared with developed regions, the penetration rate of industrial Internet platforms and intelligent manufacturing systems remains relatively low. Digital technology application is often limited to isolated production links rather than integrated across the entire value chain.

3.3. Integration Challenges

Integration between the digital economy and manufacturing in Jilin Province is still in its early stages. Many enterprises lack systematic digital transformation strategies, and uncertain digital investment returns further constrain their willingness to transform.

4. CHALLENGES FACED BY INDUSTRIAL ENTERPRISES IN DIGITAL TRANSFORMATION IN JILIN PROVINCE

Jilin Province has played a crucial role in China's industrialization process. However, as high-tech industries developed and productivity improved in light industrial products, Jilin's traditional manufacturing industry once fell into a slump (Li & Ma, 2022). Jilin Province is a major old industrial base in China, with an industrial economy centered on traditional industries such as automotive manufacturing, petrochemicals, and equipment manufacturing. During digital transformation, Jilin Province faces multiple structural and phased challenges. The core pain points are concentrated at the foundational support level: the construction of digital infrastructure lags behind, the number of industrial internet platforms is insufficient, and their functions are incomplete; cross-platform operability is poor; the digital transformation rate of traditional production equipment is low, and a large number of outdated devices lack digital interfaces, making it difficult to achieve digital control of the production process. At the same time, the local digital service ecosystem is incomplete and lacks professional technical service providers to offer customized solutions. Enterprises often encounter technical bottlenecks in areas such as industrial software applications and data security protection. The talent shortage also limits the digital transformation of private enterprises in Jilin Province, as shown by a lack of high-end digital talent and difficulty retaining local technical workers.

Beyond insufficient basic support, the digital transformation of industrial enterprises in Jilin Province also faces deep-seated obstacles, especially in industrial collaboration and the external environment. In the industrial ecosystem, digitalization levels across the upstream and downstream of the industrial chain are unbalanced, and a digital divide exists between core enterprises and small and medium-sized supporting enterprises. A lack of data-sharing and collaboration mechanisms hinders synergy in the industrial chain's digital transformation. Moreover, the deep integration of digital technology and industry is insufficient. In the external environment, the targeted policy support system is still imperfect, the digital asset property rights protection system is incomplete, and market supervision mechanisms have not adapted to the new business models brought about by digital transformation, further complicating and intensifying the challenges of transformation.

5. ANALYSIS OF THE PROBLEMS IN PROMOTING THE TRANSFORMATION AND UPGRADING OF MANUFACTURING ENTERPRISES IN JILIN PROVINCE BY DIGITAL ECONOMY

5.1. Lack of independent innovation capacity and core technologies

In recent years, Chinese manufacturing enterprises have developed rapidly, and traditional industrial enterprises have also shown strong momentum in economic growth. However, significant problems have emerged during digital transformation. In independent research and development and technological innovation, they have lagged far behind the transformation of manufacturing enterprises. As a result, manufacturing enterprises in Jilin Province are overly dependent on other developed countries for many core technologies, leading to weak independent innovation capacity and a significant reduction in their products' market competitiveness. Fundamentally, the digital transformation of manufacturing enterprises is based on a weak foundation. Whether in research and development capabilities, supporting facilities, or professional talent, these factors have limited core technology research and development in manufacturing enterprises. The digital economy relies on high-tech. If they fail to seize the next opportunity for economic growth, transforming manufacturing enterprises will become even more difficult. Therefore, enterprises must grasp the challenges and opportunities of the digital economy era, accelerate resource investment and talent recruitment, prioritize core technology research and development, and increase R&D rewards to better adapt to the digital economy's development trend.

5.2. Data security issues are difficult to guarantee

The digital economy has brought many benefits to enterprises' sustainable development, but data security has also become a major challenge. Because data centers support many business strategies and hold enterprises' internal secrets, ensuring information security has become a key factor hindering enterprise digital transformation. Manufacturing enterprises in Jilin Province that want to transform through the digital economy must be centered on the Internet and closely connected to it, inevitably creating security issues. As digitalization advances, network viruses and attack methods proliferate, and enterprises often lack advanced technical means to defend against external intrusions. On the other hand, digital attacks are difficult to trace to their sources, are highly concealed, and make it hard to find fundamental solutions. Moreover, information leakage can cause irreparable damage to enterprises. When manufacturing enterprises transmit, store, and share data, data security is beyond doubt. Because manufacturing enterprises cover multiple processes, such as raw material procurement, product production, marketing, and financial and non-financial data, a data security issue at any link can leak major enterprise secrets, causing irreversible losses and harm to the enterprise and its customers.

5.3. There is a shortage of talent in the field of digital transformation

The digital economy is developing rapidly within China, but there is a relative shortage of talents and experts proficient in digital transformation. Because specialized training institutions for digital talent are scarce, the reserve of digital transformation talent is seriously insufficient, especially in some key manufacturing industries, where the shortage is even more pronounced. This has greatly limited Chinese manufacturing enterprises' ability to integrate and apply digital technologies. Personnel in most manufacturing enterprises are broadly divided into ordinary workers, technical workers, and management personnel. China lacks high-level digital technology R&D talent, high-skilled product production talent, and high-level project management talent, especially professional compound technical talent proficient in information technology, production technology, and management, who can directly engage in the digital operation and management of manufacturing enterprises. The lack of a training and management system for high-tech, high-precision digital technology talent to some extent hinders enterprises' digital development. Currently, China's 5G technology is a global leader, but it lags behind developed countries in new technologies such as big data, artificial intelligence, cloud computing, and the Internet of Things. Chinese manufacturing enterprises have abundant labor resources, but a shortage of digital talent leaves many problems in data storage and transmission. Ensuring the safety and efficiency of enterprise information management has become a key issue.

5.4. Laws and policies lag behind the practical development of the digital economy

The country has successively formulated the "E-commerce Law" and the "Data Security Law", aiming to protect the legitimate rights and interests of individuals and enterprises, promote the development and utilization of data, and ensure data security. However, as digital transformation progresses, data has become a key production factor, and secure storage and efficient transmission have become crucial. Strengthening standardized management of digital centers and clarifying penalties and responsibilities for data crimes and related issues still need further improvement.

In terms of policy support, the promulgation and implementation of documents such as the "Guiding Opinions on Actively Promoting the 'Internet Plus' Action" and "Made in China 2025" have provided certain policy guidance for digital transformation. However, these policies lack personalized provisions, and most methods for integrating digital technology into manufacturing business processes are general. Digital transformation is a long-term, continuous process, and it risks causing job losses if the transformation fails. Currently, government departments lack a comprehensive top-level design for these risks, and support funds still need to be increased.

6. COUNTERMEASURES AND SUGGESTIONS FOR THE TRANSFORMATION AND UPGRADING OF MANUFACTURING ENTERPRISES IN THE CONTEXT OF THE DIGITAL ECONOMY

6.1. Increase investment in and support for scientific research

Against the background of the digital economy, the key to promoting the digital transformation and high-quality development of manufacturing enterprises lies in science and technology. Therefore, manufacturing enterprises need to accelerate technological innovation and R&D. First, prioritize innovation in products and core technologies. Increase investment and support for scientific research, and integrate digital technologies such as big data, the Internet, and artificial intelligence into various production and management processes to promote the rapid integration and development of the digital economy and manufacturing enterprises. Second, attach importance to informatization. By emphasizing research and development, continuously strengthen the development of information system basic platforms and gradually improve them in line with enterprises' actual development, laying a solid foundation for the transformation and upgrading of manufacturing enterprises. Only by closely integrating the digital economy and information technology departments, production departments, management departments, financial departments, and some important business processes to meet the actual operational needs of enterprises can we better promote the research and development of core products and the improvement of self-innovation capabilities of enterprises, thereby achieving the innovation of enterprise production and operation activities through high-tech. Finally, make full use of the existing policy incentives and financial support. China has taken the digital economy as an important national development strategy. With policy support, some industrial Internet platforms have achieved large-scale commercialization, not only providing favorable resources for the digital configuration of manufacturing enterprise production and operation processes, but also providing guarantees and support for accelerating intelligent manufacturing.

6.2. Attach great importance to the construction of data security

For manufacturing enterprises, building data security is crucial, as it provides a strong guarantee for stable business operations and market competitiveness. China's strategic orientation shows that the country attaches great importance to data security and places it at the core. On this basis, relevant departments should further strengthen network supervision, ensure the secure storage and transmission of manufacturing enterprises' data, increase penalties for malicious data leakage, and crack down on illegal activities. From the perspective of enterprises, first, they should prioritize building information security human resources by holding lectures and sending employees for external training to cultivate data analysts and information security analysts, and enhance employees' awareness of data security prevention. Second, they should strengthen data security infrastructure, improve data security defense systems, and prevent external hacker attacks by introducing advanced domestic and foreign data firewalls. At the same time, they should encourage enterprises to independently develop data security defense software and protect data centers by using high-tech data encryption methods, complex programming, and algorithms. In each business process, they should also set the scope of system login rights and responsibilities to prevent data leakage caused by unauthorized operations. At the same time, they should ensure effective data backup to reduce losses from accidental data loss.

6.3. Strengthen the cultivation of digital talents

In the era of the digital economy, society no longer needs single-professional talents, but high-end compound talents proficient in big data analysis and skilled at integrating data and industry. To cultivate digital technology talent, the government, schools, and enterprises should all step up their efforts. At the enterprise level, they should strengthen cooperation with research and training institutions, regularly provide digital technology training for management personnel and production technicians, and promote the development of digital innovation teams, digital demonstration bases, and talent training platforms. They should also introduce advanced digital talent through various recruitment methods to inject new vitality into enterprises' digital development. The state should also support digital talent cultivation through policies and funding, and guide enterprises to build practical, effective social training platforms and digital talent cultivation mechanisms through measures such as system guidance and tax reductions. In terms of talent cultivation in colleges and universities, each university should improve the talent cultivation model of school-enterprise

cooperation, set up big data-related courses according to their own professional characteristics, and improve the professional talent cultivation plan according to the talent standards required by enterprises, so as to provide more high-quality and high-level compound talents in digital technology for society.

6.4. Improve relevant laws, regulations and policies to promote digital transformation

Manufacturing enterprises need to adapt to the trend of digital demand and develop in the direction of platformization, networking, intelligence and service orientation. Currently, the digital transformation of the manufacturing industry has entered a more pragmatic stage. It is necessary to accelerate improvements to laws and regulations to provide a sound legal environment for manufacturing enterprises. First, the state should promptly introduce relevant legal preferential measures to encourage the digital transformation of the manufacturing industry. The funds and risks that manufacturing enterprises face during transformation and upgrading are huge. On the one hand, the government can reduce enterprises' tax burden through tax reductions and additional deductions, and provide low-interest loans to enterprises that meet the transformation conditions. Secondly, as the digital economy continues to develop, legislative protection work should also be continuously updated. The legislative department should continually improve the legal protection system, increase penalties for illegal infringement, further refine legal provisions, and add operational and application guidelines to ensure the smooth progress of digital transformation.

As the integration of industrialization and informatization continues to advance in our country, the manufacturing industry should pay more attention to its own digital transformation. During the manufacturing transformation process, the government has played a crucial role. Therefore, the government should introduce guiding policies related to the development plan of the big data industry, mainly providing support and guarantees in aspects such as platform construction, facility provision, network security, and demonstration promotion, to assist manufacturing enterprises in building an information infrastructure and offer support for subsequent updates, renovations, and application promotion. At the same time, in light of the actual development of enterprises, it should provide matching funds for top-level design and talent reserves, make strategic and directional plans and layouts for the transformation and upgrading of the manufacturing industry, and introduce relevant financial preferential policies to solve the problems of enterprise financing difficulties, talent shortages, and worker unemployment. As the digital economy and the real industrial sector continue to integrate, and digital production management improves, employees engaged in repetitive work may face unemployment. The government should implement proper placement measures for laid-off employees. At the same time, it should improve the vocational education system, enhance enterprises' and training institutions' talent-innovation awareness, encourage on-the-job employees to receive digital skills training, and increase support for cultivating compound innovative talents in key industries.

7. CONCLUSION

To meet the practical demands of digital transformation for manufacturing enterprises in Jilin Province in the era of the digital economy, this paper analyzes the background and challenges of manufacturing enterprises' transformation and upgrading in Jilin Province. The digital transformation and upgrading of manufacturing enterprises is an inevitable trend. Enterprises should combine their own advantages, increase investment in scientific research and support, attach importance to the construction of data security, strengthen the cultivation of digital talents, and fully utilize the support of national laws and policies to actively promote the effective integration of industrialization and digitalization, add vitality to the quality improvement and efficiency enhancement of traditional manufacturing, and hope that the research in this paper can provide effective references and suggestions for the digital transformation and sustainable development of traditional manufacturing enterprises.

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9. CONFLICT OF INTEREST

The authors declare no known competing financial interests or personal relationships that could have influenced the work reported in the paper.

10. AUTHOR CONTRIBUTION STATEMENT

Jia Kai, Mohamad Nasir Saludin, and Muhammad Omar jointly contributed to the study's conceptualization and development. The authors were involved in the research design, literature review, analysis and interpretation of the findings, and manuscript preparation. All authors contributed to the critical review and revision of the manuscript, approved the final version for publication, and agreed to be accountable for the accuracy and integrity of the work.

11. ETHICS STATEMENT

This study did not involve human participants, personal data, clinical interventions, or animal subjects. The research used secondary data, published literature, policy documents, and publicly available information. Therefore, formal ethical approval and informed consent were not required. The authors conducted the study in accordance with established principles of research integrity, including appropriate citation and acknowledgment of all sources used. All authors have reviewed and approved the final manuscript and accept responsibility for the integrity of the work.

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