ISSN: 2664-9640

Research on the Digital Transformation and Development of Small and Medium-sized Manufacturing Enterprises

Mingqiang Gu*

Hangzhou Royce Import & Export Co., Ltd., Hangzhou 310014, Zhejiang, China

*Corresponding author: Mingqiang Gu (Email: gmqcn@alldiamondtools.com)

Abstract

This paper focuses on the digital transformation of small and medium-sized manufacturing enterprises, expounds its significance for the contemporary economy, and points out that although they face problems such as a shortage of professional talents, lagging business concepts, and insufficient precision of policy support, they can still achieve transformation and development with the help of information and digital technologies. The paper analyzes in detail the application scenarios of big data, artificial intelligence, and the Internet of Things in the manufacturing industry, and proposes implementation paths such as creating intelligent production and supply chain systems and using digital twins to optimize product design, aiming to help small and medium-sized manufacturing enterprises enhance their competitiveness through digital transformation and achieve sustainable development.

Keywords

Small and Medium-sized Manufacturing Enterprises; Digital Transformation; Digital Technology; Implementation Path; Intelligent Production; Product Design Optimization.

1. Significance and Importance of the Digital Transformation of Small and Medium-sized Manufacturing Enterprises

Today, with the rapid advancement of the digital wave, the number of small and medium-sized enterprises in China has exceeded 60 million, accounting for 94.5% of the total number of domestic enterprises.[1] They have become an important engine for economic development. They play an indispensable role in promoting employment, enhancing market competitiveness, and stimulating the overall vitality of the economy. With the rapid progress of digital technology, technologies such as big data, artificial intelligence, and the Internet of Things have become new engines for boosting the economy. Many enterprises have used these advanced technologies for digital transformation, conducting in-depth reforms and innovations in research and development, production, and management, thus building their core competitiveness. This not only promotes the rapid growth of enterprises but also leads the upgrading and transformation of the entire industrial chain.

Small and medium-sized manufacturing enterprises are restricted by factors such as scale, capital, and technical strength, and face many challenges in digital transformation.[2] However, they can also achieve effective performance improvement through cost-reduction, efficiency-enhancement, and innovation paths. Digital technology makes the information of all parties in the market more transparent, reducing the costs of information search, negotiation, and contract signing for enterprises. At the same time, it also saves operating expenses in procurement, marketing, logistics, and other links, enabling enterprises to break through time and space limitations and provide customers with satisfactory services. In the process of promoting enterprise innovation and upgrading, new digital technologies can effectively activate the innovation elements of enterprises, fully release innovation potential, and thus

ISSN: 2664-9640

promote the in-depth integration of new and old businesses in multiple dimensions such as resources, technology, and experience. At the same time, these technologies can also provide customers with equipment upgrade and operation and maintenance value-added services, building a new "product + service" model and opening up new profit spaces for enterprises.

2. Current Situation and Problems of the Digital Transformation of Small and Medium-sized Manufacturing Enterprises

At present, most small and medium-sized manufacturing enterprises in China are still in the stage of traditional manufacturing methods, and the process of digital development and transformation is slow.[3] The "Manufacturing Digital Transformation Action Plan" points out that the digital transformation of the manufacturing industry is an important measure to promote new-type industrialization and build a modern industrial system. It is necessary to increase support for the digital transformation of small and medium-sized enterprises and explore and form a long-term mechanism to promote the digital transformation of small and medium-sized enterprises. The "Key Points of Digital Economy Work in 2024" points out that it is necessary to deeply promote the digital transformation of industries, deepen the intelligent transformation, digital transformation, and networking of the manufacturing industry, vigorously promote the digital transformation of key areas, and create a digital transformation ecosystem. Although the government's policy guidance and support assist the digital transformation of small and medium-sized manufacturing enterprises, most enterprises still face many problems.

Small and medium-sized manufacturing enterprises generally face a shortage of digital talents. Due to limited enterprise scale, low brand awareness, and insufficient social recognition, these enterprises find it difficult to attract professional digital talents. At the same time, internal cultivation of professional technical talents also faces challenges, including limited development space and uncompetitive treatment, resulting in poor talent stability. In addition, many small and medium-sized manufacturing enterprises originated from individual businesses in towns or villages. Their owners often have insufficient awareness of modern digital operation concepts and find it difficult to deeply understand the importance and timeliness of digital transformation. Therefore, they are reluctant to invest additional funds to promote enterprise upgrading. Fine-grained policy support can also strongly promote the digital transformation of enterprises. Given the differences in digital transformation paths among industries and the uniqueness of the problems faced by enterprises, local governments need to visit enterprises to understand their real situations and then provide more targeted support policies.

3. Analysis of the Core Application Scenarios of Information and Digital Technologies in the Manufacturing Industry

The traditional production management mode relies on experience and static data and is difficult to adapt to the rapid changes of the market.[4] It has obvious deficiencies in effectiveness and flexibility. New technologies such as big data, artificial intelligence, and the Internet of Things can greatly improve the efficiency and quality of enterprise production management through real-time data collection, intelligent analysis, and automated operations.

3.1. Intelligent Decision-Making Support based on Big Data

In the traditional mode, managers make decisions using limited historical data and subjective experience, which is easily affected by incomplete information and subjective biases, leading to decision-making errors. By building a big-data-driven intelligent decision-making system and using in-depth data analysis, the efficiency of enterprise production planning, inventory, and

ISSN: 2664-9640

logistics decision-making can be improved, and the enterprise's response ability to market changes can be strengthened, helping the enterprise to make more efficient decisions. During the peak production season, the system can accurately predict sales growth, thereby improving production efficiency and increasing inventory, effectively avoiding order backlogs or losses. In the off-season, the system will issue timely warnings to guide the enterprise to reduce production and inventory to avoid unnecessary waste of resources.

By using the in-depth analysis capabilities of big data, enterprises can continuously monitor and analyze data, and then flexibly adjust equipment and production plans to achieve intelligent decision-making. For example, using the clustering analysis algorithm, the energy efficiency status of production equipment can be accurately evaluated based on its operating parameters, providing targeted guidance for equipment maintenance and upgrading. Using the association rule algorithm, the relationships between various data links in the production process can be explored in depth, identifying the key factors causing product defects and providing a solid basis for the optimization and adjustment of production parameters.

3.2. Automated Production based on Artificial Intelligence

The traditional production mode relies on fixed procedures and manual operation experience to control equipment. However, when dealing with complex process changes and sudden equipment failures, the response is often slow, affecting product quality. Especially for high-precision parts products, the interference of manual operation may prevent the equipment from reaching the required precision standards. An intelligent automated production system built with the help of AI technology integrates robotics and advanced algorithms, aiming to reduce labor requirements, relieve work intensity, and can use real-time production data to detect potential problems, effectively shortening the unexpected downtime of equipment.

An intelligent and adaptive production mode enables enterprises to stay ahead in a complex and changeable market and effectively respond to supply chain fluctuations and industry competition. Using the linear regression algorithm, historical order quantities, equipment production capacities, raw material supplies, and other data are used as input features, and the production completion time is used as the output label to establish a mathematical model of the production cycle, and a reasonable and efficient production scheduling plan is developed based on the model. The decision-tree algorithm constructs decision rules for judging product quality based on characteristics such as temperature, pressure, and processing time during the production process, and can quickly determine whether a product is qualified.

3.3. Full-Process Production Monitoring based on the Internet of Things

The Internet of Things system monitors core data such as equipment status and temperature around the clock through sensors and immediately feeds back this information to the monitoring center to achieve comprehensive production management. Relevant personnel can intervene in a targeted manner according to the production status and abnormal situations reflected by the data, effectively reducing the possibility of production interruptions.[5] A comprehensive production process monitoring system built with the help of the Internet of Things technology helps enterprises achieve transparent and visual management, thereby enhancing operational flexibility and rapid response capabilities. The Internet of Things is applied throughout the entire process from raw materials to finished products, and can immediately issue alarms for problems that occur, ensuring the smooth progress of the production process and reducing the monitoring burden on managers. For enterprises, achieving transparent monitoring and management of the production process can optimize production management efficiency, enhance the controllability of the production process, and strengthen the collaboration capabilities of enterprises with all links of the industrial chain.

ISSN: 2664-9640

4. Implementation Paths for the Digital Transformation of Small and Medium-sized Manufacturing Enterprises

4.1. Creating an Intelligent Production and Supply Chain System

Digital technology empowers product production. Creating intelligent production lines and building a supply chain system, and giving full play to network collaboration, helps to improve the utilization rate of production resources.[6] First, small and medium-sized manufacturing enterprises should strengthen the control of product quality and production processes according to product delivery requirements, build intelligent production lines, and skillfully use intelligent production models to improve the utilization efficiency of production resources. Second, the enterprise's technical team should implement centralized control, collect production data, and build a system model to achieve comprehensive interconnection of production resource information. Finally, integrate production resources, build a diversified and collaborative supply chain network, realize cloud sharing of production and service information, promote the innovative combination of internal and external resources, and help the synchronous development of the entire industrial chain.

4.2. Optimizing Product Design Using Digital Twins

Digital twin technology has advantages such as real-time mapping and synchronous tracking. It integrates multiple disciplines and multiple physics, realizes efficient human-machine interaction, can effectively reduce the difficulty of extracting product research and development information, and reduce design errors. First, technicians use digital twin devices to collect and map physical objects into virtual space to obtain key product information, effectively reducing the difficulty of product design. Second, using the key product information obtained by digital twin technology, product research and development is carried out on intelligent production lines.[7] Technicians can track product indicators in real-time, analyze design defects, and take timely intervention measures to avoid waste of production resources. Finally, small and medium-sized manufacturing enterprises should build a testing platform, strengthen the joint debugging of products online and offline, reduce the time required from product design to production, and form an efficient product optimization design system.

4.3. Deepening the Digital Management of the Product Life Cycle

Product life cycle management is an important part of the application of enterprise digital technology and a necessary path for enterprise digital transformation. Enterprises should use technologies such as big data analysis and cloud computing to optimize the functional architecture of the PLM system, covering the entire life cycle with digital technology, providing guarantee for enterprise product production and sales. It also helps to improve the unity of enterprise management and achieve efficient collaboration of the industrial chain and supply chain. In addition, using digital technology to mark product production modules helps with subsequent traceability management. For product quality problems, it is possible to accurately analyze the flaws in the production process and strengthen subsequent management to ensure product production quality.

4.4. Promoting the Collaborative Innovation and Development of New Technologies

Enterprises should use new technologies as examples, give play to the leading role of new technologies, and promote the collaborative development of product research and development and design. Through the in-depth integration of big data analysis, AI technology, blockchain, and cloud computing, expand application scenarios, accelerate the transformation of new technologies, achieve comprehensive sharing of digital information, and promote the digital transformation of production lines. In terms of collaborative resource allocation,

ISSN: 2664-9640

enterprises should make full use of the functional advantages of software, use professional tools to build an efficient centralized management control system, and ensure the accurate allocation of human, material, and financial resources according to the resource requirements of each link from product research and development to production and sales. In terms of the collaborative optimization of the capital flow and information flow, enterprises should deeply integrate digital technology with the management of enterprise capital and information flow, respond to market changes by scientifically formulating capital budgets and investment decisions, and at the same time break down information barriers to achieve real-time sharing of the entire process information from procurement to after-sales, thereby improving operation efficiency and strengthening market competitiveness.

4.5. Building an Intelligent Manufacturing Collaborative Innovation Platform

Build an intelligent manufacturing collaborative innovation platform, continuously introduce new functions and technologies, enhance the innovation ability and competitiveness of the platform, and provide a solid guarantee for the intelligent manufacturing transformation of enterprises. First, it is necessary to clarify the goals, functions, scope of application, and expected effects of the platform, establish necessary technical infrastructure, and create and optimize a collaborative working environment. The innovation platform requires the support of a cloud computing big-data platform, and build a comprehensive and interconnected Internet of Things network to connect the entire process of product research and development, production, and sales, which helps to improve communication efficiency and collaboration effects among teams.

5. Conclusion

As an important part of the contemporary economy, small and medium-sized manufacturing enterprises should follow the trend of the times and actively carry out enterprise digital transformation. On the one hand, digital technology can help enterprises reduce costs, increase efficiency, and drive innovation. On the other hand, enterprises often encounter problems such as a shortage of digital professionals, backward concepts, and inaccurate policy support. To promote the digital transformation process of small and medium-sized manufacturing enterprises, enterprises should establish intelligent production and supply chain systems, strengthen the digital management of the entire product life cycle, and focus on building an intelligent manufacturing collaborative innovation platform. At the same time, the government should continuously optimize the policy support framework, deeply understand the real needs of enterprises, and provide them with more accurate policy guidance and support. With the joint efforts of the government and enterprises, small and medium-sized manufacturing enterprises can smoothly embrace digital innovation, move towards sustainable development, and contribute new impetus to economic progress.

References

[1] Zhang Xiaheng. Obstacles, Driving Factors, and Path Dependence of the Digital Transformation of Small and Medium-sized Enterprises: Based on a Survey of 377 Small and Medium-sized Enterprises in the Tertiary Industry [J]. China Business and Market, 2020, 34(12): 72-82. DOI: 10.14089/j.cnki.cn11-3664/f.2020.12.008.

[2] He Fan, Liu Hongxia. Evaluation of the Performance Improvement Effect of the Digital Transformation of Real Enterprises from the Perspective of the Digital Economy [J]. Reform, 2019,(04): 137-148.

[3] Fei Qiang, Li Yunji, Dong Guiping, et al. Research on the Digital Development and Implementation Path of Traditional Manufacturing Industries: Taking Small and Medium-sized Manufacturing

ISSN: 2664-9640

Enterprises in Wuxi as an Example [J]. Journal of Wuxi Institute of Technology, 2025, 24(01): 56-60. DOI: 10.13750/j.cnki.issn.1671-7880.2025.01.011.

[4] Xu Ke. Research on the Optimization Strategy of the Production Management System under the Background of Digital Transformation [J]. Enterprise Reform and Management, 2025,(05): 15-17. DOI: 10.13768/j.cnki.cn11-3793/f.2025.0264.

[5] Chen Lei, Ma Huijie, Zhou Yanqiu. Antecedent Configurations, Model Selection, and Promotion Strategies of Enterprise Digital Transformation [J]. Reform, 2024,(07): 65-79.

[6] Xu Mingchen, Liu Heng. Research on the Digital Transformation of Advanced Manufacturing Enterprises and Their Empowerment Modes for Small and Medium-sized Enterprises [J]. Price: Theory & Practice, 2024,(06): 143-148. DOI: 10.19851/j.cnki.CN11-1010/F.2024.06.223.

[7] Yang Zongjian. Analysis of the Digital Transformation Path of Product Research and Development of Traditional Manufacturing Enterprises [J]. China Information Times, 2024,(08): 52-54.