

The Impact of Digital Transformation of Manufacturing Enterprises on the Advancement of Global Value Chain Status

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Abstract: Driven by the wave of globalisation and digitalisation, manufacturing enterprises are facing the urgent need for transformation and upgrading. This study focuses on the role of digital transformation of manufacturing enterprises on their position enhancement in the global value chain, and explores the key elements of digital transformation and its influence mechanism through literature review and theoretical analysis. It is found that digital transformation can significantly enhance the position of manufacturing enterprises in GVCs by improving production efficiency, enhancing innovation capability and optimising resource allocation. The application of digital technology not only reduces production costs, but also promotes the innovation of enterprise business models, enabling enterprises to better adapt to changes in the global market. Based on the conclusions of the study, this study proposes to increase the investment in digital technology R&D, strengthen the training and introduction of talents, and promote the change of enterprise organisational structure and other strategic recommendations, in order to help manufacturing enterprises better cope with the challenges of digital transformation, enhance their position in the global value chain, and achieve sustainable development.

Keywords: Digital transformation; Global value chains; Manufacturing companies; Supply chain collaboration.

1. Introduction

In the context of global economic integration, manufacturing enterprises are faced with the challenges of intensified international competition, changing market demands and complex supply chains, and urgently need to enhance their competitiveness through digital transformation. With the help of big data, artificial intelligence and other technologies, digital transformation can realise production intelligence, management refinement and business model innovation, helping enterprises to adapt to market changes and enhance their position in the global value chain.

Traditional manufacturing industries are mostly at the low end of the global value chain, with low value-added and thin profits. Digital transformation provides an opportunity for enterprises to break through bottlenecks and move towards higher value-added segments. By optimising production processes, strengthening supply chain collaboration and promoting data-driven innovation, enterprises can improve productivity, product quality and market responsiveness. Research on the impact of digital transformation on the improvement of global value chain status can reveal its mechanism of action, provide theoretical support and practical guidance for enterprises to formulate digital strategies, and promote the high-quality development of the manufacturing industry.

This study focuses on the mechanism and path of digital transformation of manufacturing enterprises on the improvement of their position in global value chains. The research objectives include: analysing the connotation and path of digital transformation; analysing its effect on the improvement of production efficiency, innovation capability and supply chain synergy; and constructing theoretical models and empirical frameworks to verify the relationship between the two. The study adopts literature review, case

analysis and empirical research methods, and builds a comprehensive analysis framework based on global value chain theory, industrial digitalisation theory and enterprise capability theory, aiming to fill the gaps in related research and provide theoretical basis and decision-making reference for enterprise digital transformation.

2. Literature Review

2.1. Studies on Digital Transformation of Enterprises

The concept of digital transformation was first proposed by Cartner in 2011, and digital transformation means that enterprises use digital technologies and capabilities to drive innovation and transformation of their business and business models. Some scholars have studied the influencing factors of sustained innovation in enterprises. From the internal perspective, scholars have focused on factors such as financing constraints and executive characteristics; from the external perspective, scholars have studied factors such as policy environment and government subsidies. The essence of enterprise digital transformation is to realise enterprise innovation through technological transformation, and in this process, enterprises need to invest high transformation sunk costs and a longer period of time, thus facing higher risks. More enterprises are facing the dilemma of "not willing to turn, not dare to turn, will not turn", but digital transformation is not an optional question, but a mandatory question. At present, the research on the impact of enterprise digital transformation on enterprise continuous innovation is extremely weak. It is of great theoretical significance and practical significance to study the consequences and mechanisms of the impact of digital transformation on the continuous innovation of enterprises.

2.2. Studies on the Climb Up the Global Value Chain Hierarchy

The theory of climbing global value chain originates from the value chain theory represented by Porter in the 1980s, in which differences in value-added capacity or efficiency of different links of the value chain determine the status of division of labour and trade interests of countries. Liu Zipeng (2023) and others empirically found that geographic location and industry production scale play a driving role in the upgrading of global value chain status. Based on the perspective of global value chain, Wang Ling and Huang Rong (2023) study the impact of digitalisation on the position of manufacturing GVCs, and find that digital inputs are conducive to the improvement of the position of manufacturing GVCs, and that the degree of specialisation and product diversity are the two mechanisms by which digital inputs contribute to the upgrading of the position of GVCs. Zuo et al. (2024) propose an indirect path of reconstructing domestic and regional value chains and integrating global value chains in the reverse direction, with a view to providing theoretical support for the upgrading of China's manufacturing cluster network in the global value chain and deepening the understanding of the field of value chain upgrading.

2.3. Study on the Digital Transformation of Enterprises for Climbing Up Global Value Chains

Wu, Dailong, and Liu, Liping (2022) conducted an empirical test using data from A-share listed companies and found that the digital transformation of enterprises has a positive effect on the climb of global value chains. Sun Minggao (2023) examined the relationship between GVC embeddedness and the cultivation of industrial competitive advantage at the indirect level based on sample data of prefecture-level cities. The study concludes that global value chain embedding can effectively enhance China's industrial competitive advantage and help China's industrial structure upgrade. Ma Xiaodong and He Lunzhi (2018) conducted a study on whether China's integration into global value chains can promote the upgrading of China's industrial structure using the PCSE method and the Newey-West method.

2.4. Literature Review

Numerous scholars have provided insights into the digital transformation of firms and how this transformation contributes to the upgrading of firms' position in global value chains through an interdisciplinary research perspective, and these explorations have shed important light on this topic. However, the existing literature still has certain shortcomings in terms of empirical research. In particular, there is a relative paucity of systematic empirical evidence exploring the specific link between firms' digital transformation and GVC participation. Most studies focus on theoretical elaboration and qualitative analysis, while there is a lack of sufficient data support and empirical tests on how digital transformation quantitatively affects firms' position in GVCs and how to climb up the value chain through specific digital practices.

3. Analysis of the Impact of Digital Transformation on the Position of Manufacturing in Global Value Chains

3.1. Key Elements of Digital Transformation

Against the backdrop of increasingly fierce competition in global value chains, the digital transformation of manufacturing enterprises has become a key initiative to enhance their international competitiveness. Digital transformation involves a few key elements that interact with each other to promote the upgrading of an enterprise's position in a global value chain.

3.1.1. Digital infrastructure development

As the cornerstone of digital transformation, digital infrastructure provides enterprises with strong technical support. The improvement of infrastructure such as high-speed Internet, cloud computing platforms and big data centres can not only enhance the data processing capacity of enterprises, but also optimize the production process and realize intelligent manufacturing. For example, through the industrial Internet platform, enterprises can monitor the operating status of production equipment in real time and predict potential failures in advance, thus reducing downtime and improving production efficiency. Studies have shown that the degree of digital infrastructure is positively correlated with the productivity and innovation capacity of enterprises, and is the basic guarantee for enterprises to enhance their position in the global value chain.

3.1.2. Technological innovation capacity

Technological innovation is the core driver of digital transformation. By introducing advanced technologies such as artificial intelligence, Internet of Things and blockchain, enterprises can optimise production processes, improve production efficiency, reduce production costs and develop more competitive products and services. For example, by optimising the structural design of big data storage equipment, Yueyun Digital Intelligence has significantly improved maintenance efficiency and security, providing new ideas for the digital transformation of enterprises. Technological innovation not only improves productivity, but also expands the business boundaries of enterprises by developing new products and services. In the process of digital transformation, enterprises should focus on investing in technology R&D and enhancing their independent innovation capabilities in order to occupy a more favourable position in the global value chain.

3.1.3. Data management and analysis capacity

Data is one of the key elements of digital transformation. Enterprises need to have efficient data collection, storage, processing and analysis capabilities in order to extract data from massive amounts of data to support decision-making. Through data-driven decision-making, enterprises can predict market demand trends, optimise inventory management, and reduce the risk of inventory backlogs and stock-outs. For example, enterprises can optimise supply chain management through data analytics to achieve accurate procurement and production planning, thereby reducing operating costs and improving market responsiveness. The improvement of data management and analysis capabilities can enable enterprises to maintain their competitive advantage in the fierce market competition and enhance their position in the global value chain.

3.1.4. Talent pool and training

Digital transformation needs to be supported by talents with digital skills. Enterprises need to strengthen the training and introduction of talents to enhance the digital skills and literacy of employees. For example, by carrying out digital literacy skills enhancement actions and strengthening the training of composite talents, enterprises can provide intellectual support for digital transformation. Talent is the core resource of enterprise digital transformation, only with high-quality digital talent, enterprises can make breakthroughs in technological innovation, management optimisation and business model innovation, so as to climb up the global value chain.

3.2. Impact of Digital Transformation on The Competitiveness of Manufacturing Companies

The impact of digital transformation on the competitiveness of manufacturing companies is multifaceted, covering multiple dimensions such as technological innovation, management optimisation and supply chain integration.

3.2.1. Technological innovation

Technological innovation is the key to improving the competitiveness of enterprises. Digital transformation can enhance an enterprise's ability to innovate through the introduction of new technologies. For example, enterprises can optimise product design through big data analysis and achieve remote monitoring and maintenance of equipment through IoT technology. Technological innovation not only improves productivity, but also expands the business boundaries of enterprises through the development of new products and services. Studies have shown that digital transformation can significantly increase an enterprise's investment in technological innovation, which in turn improves its performance. In the process of digital transformation, enterprises should focus on technology R&D investment and enhance their independent innovation capability to occupy a more favourable position in the global value chain.

3.2.2. Management optimisation

Digital transformation can optimise an enterprise's management processes and improve operational efficiency. For example, by introducing an ERP system, an enterprise can realise the information management of production, sales and purchasing, and improve the overall operational efficiency. In addition, digital transformation can also reduce internal communication costs and improve the scientific and timely decision-making by enhancing management efficiency. For example, enterprises can achieve accurate market forecasts and production plans through data analysis, thereby reducing operating costs and improving market response speed. Management optimisation is an important means for enterprises to enhance their competitiveness. Through digital transformation, enterprises can achieve automation and intelligence of management processes and improve overall operational efficiency.

3.2.3. Supply chain integration

Digital transformation can improve the efficiency and resilience of the supply chain through the digitisation of supply chain management. For example, by establishing a digital supply chain platform, enterprises can realise real-time interaction and sharing of information in all segments of the

supply chain, reducing inventory costs and logistics costs. In addition, digital transformation can also improve the responsiveness of the supply chain by optimising the resource allocation of the supply chain. For example, enterprises can optimise supplier selection and procurement planning through data analysis to achieve accurate management of the supply chain. Supply chain integration is an important way for enterprises to enhance their competitiveness. Through digital transformation, enterprises can achieve intelligent management of the supply chain and improve the efficiency and resilience of the supply chain.

3.3. Dynamic Impact of Digital Transformation on The Position of Manufacturing Firms in Global Value Chains

The dynamic impact of digital transformation on the global value chain position of manufacturing companies is significant, and companies need to adopt different strategies to cope with it at different stages of development.

3.3.1. Initial stage

In the early stages of digital transformation, enterprises mainly improve their productivity and management capabilities by introducing basic digital technologies and tools. For example, enterprises can improve production efficiency and reduce production costs by introducing automated production lines. At this stage, an enterprise's position in the global value chain is enhanced mainly through cost advantages. Research shows that enterprises in the early stages of digital transformation can gain a certain competitive advantage in the global market by optimising production processes and reducing operating costs. However, the competitive advantage at this stage is relatively limited, and enterprises need to further deepen their digital transformation to achieve a more comprehensive competitiveness enhancement.

3.3.2. Intermediate stage

As digital transformation deepens, enterprises are beginning to focus on technological innovation and data management capabilities. For example, enterprises can optimise product design through big data analytics and achieve remote monitoring and maintenance of equipment through IoT technology. At this stage, enterprises' global value chain position may be further enhanced through technological innovation and product quality improvement. Research suggests that enterprises in the middle stage of digital transformation can occupy a more favourable position in the global value chain by improving their technological innovation and data management capabilities. Enterprises need to increase their investment in technological R&D and enhance their independent innovation capabilities at this stage in order to further climb up the GVC position.

3.3.3. Maturity stage

In the mature stage of digital transformation, enterprises not only achieve comprehensive digitalisation in technology and management, but also enhance their overall competitiveness through supply chain integration and business model innovation. For example, enterprises can optimise supply chain resource allocation and reduce supply chain costs through supply chain digital management. In addition, enterprises can also expand into new markets and business areas through business model innovation. At this stage, the enterprise's global value chain position may be upgraded to the high-end value chain through the

improvement of its overall competitiveness. Research shows that enterprises in the mature stage of digital transformation can occupy a high-end position in the global value chain through comprehensive digital transformation and business model innovation. Enterprises need to continuously optimise their digital transformation strategies and enhance their comprehensive competitiveness at this stage in order to achieve a sustained upgrading of their global value chain position.

In summary, digital transformation has a significant dynamic impact on the improvement of manufacturing enterprises' global value chain status. Enterprises should formulate corresponding digital transformation strategies according to their own actual situation at different stages of development in order to achieve the sustainable improvement of their GVC status.

4. Paths and Mechanisms for Digital Transformation to Facilitate the Climbing of Manufacturing Global Value Chains

The world is currently in a period of strategic opportunity for the accelerated evolution of the technological and industrial revolutions, and the booming development and rapid upgrading of digital technologies, such as 5G, big data and cloud computing, have changed the traditional mode of production and operation and injected fresh impetus into global economic growth. Digital transformation has become a key driving force in the climb up the global value chain, with a focus on reshaping advantages, and its impact is mainly felt through the following paths and mechanisms.

4.1. Direct and Indirect Impacts of Digital Transformation on The GVC Position of Manufacturing Firms

The digital transformation of enterprises is the core driving force to move up the global value chain, mainly through the two key paths of improving total factor productivity and optimising operation and management efficiency, reshaping the competitive advantages of enterprises, and promoting their position in the global industrial division of labour system.[1]

4.1.1. Direct impacts

From the perspective of total factor productivity (TFP) enhancement, the progress in the level of production technology of enterprises is significantly characterised by the increase in TFP, which has a significant role in promoting enterprises to climb up the global value chain. The digital transformation of enterprises can achieve an effective increase in total factor productivity through multiple mechanisms. At the factor integration level, digital transformation breaks down the boundaries of traditional factors of production and promotes the in-depth integration of data and capital factors. With the help of sensors and wireless technology, enterprises can collect all kinds of data in the production process in real time and in a comprehensive manner, from equipment operating parameters to product quality information, and transmit these massive data to the data platform for in-depth analysis and mining, optimise the production process based on the results of the data analysis, adjust the process parameters, so as to improve production efficiency and product quality, and achieve the enhancement

of total factor productivity. In terms of human capital structure adjustment, digital transformation has brought about changes in production methods, with advanced machines and equipment gradually replacing low-skilled labour, and the widespread application of automated production lines and intelligent robots changing the traditional labour-intensive production mode.

4.1.2. Indirect impacts

At the level of optimising operation management efficiency, an efficient operation management system is an important cornerstone for enterprises to maintain their advantages in the global market competition and upgrade their value chains. This system requires enterprises to have the ability to capture market demand dynamics, accurately identify customer preferences, adjust product strategies, optimise pricing mechanisms and inventory management decisions in response to diversified and personalised customer demands, and at the same time ensure that the information of each link in the supply chain is highly transparent and that transaction costs are kept at a low level. The digital transformation of enterprises provides practical solutions and technical support for the improvement of operation and management efficiency. In the supply and demand matching process, digital technology breaks the traditional dependence on historical data relevance decision-making limitations, with the help of machine learning algorithms in-depth analysis of the causal relationship between decision-making variables and outcome variables, can help enterprises more accurately predict the trend of changes in market demand, timely adjustment of the production plan and resource allocation, to achieve the accurate docking of supply and demand, to avoid waste of resources and loss of efficiency due to the mismatch of supply and demand. In the production process, based on the accurate grasp of consumer preferences, enterprises can carry out flexible production mode, with the help of digital simulation, virtual reality and other cutting-edge digital technologies, visual simulation and optimisation of product design and production process.

4.2. Construction of Multi-Dimensional Evaluation System

In order to comprehensively and scientifically assess the contribution of digital transformation to the climbing of the manufacturing global value chain, it is necessary to construct a comprehensive multi-dimensional evaluation system. In the dimension of technological innovation, the intensity of R&D investment, the number of patents granted and the proportion of R&D personnel are important indicators.

The market expansion dimension focuses on international market share, customer satisfaction and the number of new markets developed. International market share directly reflects an enterprise's competitive position in the global market, customer satisfaction reflects the extent to which an enterprise's products and services meet customers' needs, and the number of new markets developed reflects an enterprise's ability and potential to expand its markets. The evaluation indicators of the value chain participation dimension include the proportion of intermediate goods exported, the proportion of global procurement and the number of cooperation projects with multinational companies. To promote the transformation of the global value chain in a sequential manner with the digital economy, focus on key common technologies in digital manufacturing and other aspects, improve the cooperation mechanism for digital transformation of the manufacturing

industry, encourage the head enterprises to build an open collaborative innovation platform, enhance the supply capacity of digital services in the manufacturing industry, and leap towards the high end of the global value chain [2].

By organically combining these dimensions and indicators, and using scientific methods such as hierarchical analysis and entropy value method to determine the weights of each indicator, and then quantitatively analysing them with the help of fuzzy comprehensive evaluation and other models, it is possible to comprehensively and systematically assess the actual effect of digital transformation on the upward climb of the manufacturing industry's global value chain. The evaluation system not only helps enterprises clearly understand their own advantages and shortcomings in the process of digital transformation, but also provides powerful data support and decision-making basis for the government to formulate relevant policies and guide the high-quality development of the manufacturing industry, so as to promote the manufacturing industry to achieve a sustained and steady rise in the global value chain.

5. Challenges, Opportunities and Strategies for Digital Transformation in the Manufacturing Industry

5.1. Transformation Challenges

Manufacturing digital transformation is a complex systematic project involving technology, talent, data governance, organisational structure and strategic synergy. Enterprises face many challenges in the transformation process, which are intertwined and form multidimensional bottlenecks that seriously constrain their development.

5.1.1. High barriers to technology investment

The core of digital transformation lies in the application of technology and innovation, but this process requires sustained high capital investment. For example, building an industrial internet platform, updating smart equipment, deploying a data centre, and other infrastructure development require not only significant upfront capital, but also long-term maintenance and upgrade costs. For SMEs, these inputs constitute significant pressure. Due to their weaker risk tolerance, transformation decisions are often more cautious, making it difficult to achieve a comprehensive upgrade of technology in a short period of time. In addition, the rapid iteration of technology also makes enterprises face higher decision-making risks when choosing technology solutions, further increasing the difficulty of transformation.

5.1.2. Structural contradiction of talents highlighted

The problem of digital skills disconnection is common in traditional manufacturing enterprises. On the one hand, the enterprise lacks composite talents who are proficient in industrial mechanism and digital technology, and such talents can combine traditional manufacturing process with emerging digital technology to promote technological innovation and business upgrading. On the other hand, the upgrading of digital literacy of enterprise employees is lagging behind, and the internal training system is difficult to match the speed of technological iteration, resulting in employees not being able to effectively utilise new digital tools and platforms in their actual work. This contradiction in talent structure forms the "manpower ceiling" of transformation, limiting the depth and breadth of enterprise digital transformation.

5.1.3. Increased data governance risks

With production data online and business processes in the cloud, enterprise data governance is facing unprecedented challenges. Data collection, storage, transmission and application processes have become more complex, and cybersecurity threats have increased. Cross-border data flows are moreover required to deal with the regulatory frameworks of multiple countries at the same time, such as the General Data Protection Regulation (GDPR) in the EU and the California Consumer Privacy Act (CCPA) in the US. Data sovereignty and privacy protection mechanisms have become the core challenges of globalised operations, and companies need to ensure data security and availability while meeting compliance requirements.

5.1.4. Significant resistance to organisational change

Traditional hierarchical structures are particularly inefficient in the digital age. Poor information transfer and cross-departmental collaboration barriers make it difficult to support the need for agile decision-making. The phenomenon of "two skins" of business processes and digital technology is widespread, leading to serious internal resource consumption. For example, after introducing a new digital system, many enterprises find that the original business processes cannot be effectively interfaced with it, resulting in idle or inefficient operation of the system. The rigidity of organisational structure not only affects the operational efficiency of enterprises, but also undermines the motivation and creativity of employees, and becomes an important resistance to digital transformation.

5.1.5. Absence of strategic synergy mechanisms

Some enterprises have a tendency of "technology blind worship" in the process of digital transformation, paying too much attention to the advancement of technology and neglecting the deep coupling with business scenarios. This phenomenon has led to the fragmentation of pilot projects, the decoupling of technology application and business value, and high trial-and-error costs. For example, some enterprises have invested a large amount of money to introduce advanced intelligent manufacturing equipment, but due to the lack of overall transformation planning, the equipment fails to give full play to its due benefits, and on the contrary, increases the operating costs of enterprises. Enterprises need to establish a complete set of strategic synergistic mechanisms to ensure that technology investment matches business needs and achieve sustainable development of digital transformation.

5.2. Transformational Opportunities

Despite the many challenges, digital transformation also brings unprecedented opportunities for manufacturing enterprises. These opportunities are not only in terms of improved productivity and reduced costs, but also in the ability of enterprises to reconstruct their competitive advantages in the global market through technological innovation and business model changes.

5.2.1. Deep changes in the production paradigm

Digital transformation is driving a deep change in the production paradigm. Through Internet of Things (IoT) technology, companies can achieve full connectivity of equipment and monitor various parameters of the production process in real time to optimise the production process. Digital twin technology can simulate process optimisation, predict equipment failures and carry out maintenance in advance, significantly improving production efficiency and

product quality. AI algorithms can dynamically regulate production parameters, further enhancing the intelligence of the production process. The application of these technologies enables enterprises to reduce product defective rate by 30%-50%, shorten lead time by more than 40%, increase energy utilisation by 20%, and significantly strengthen cost control and quality stability.

5.2.2. Supply chain resilience upgraded across the board

Digital transformation has revolutionised supply chain management. Big data-driven demand forecasting systems can analyse market dynamics in real time, improve inventory turnover, and reduce inventory backlogs and out-of-stock risks. Blockchain technology enables full-process traceability of cross-border supply chains, ensuring transparency and traceability of supply chains, and 5G+MEC architecture supports localised real-time decision-making, enabling enterprises to respond quickly to changes in the market, effectively cope with the impact of epidemics, geopolitics, and other uncertainties, and build an "agile + resilient" global supply network.

5.2.3. Value creation paradigm iteration

Digital transformation drives an iterative value creation paradigm. Intelligent hardware (e.g., industrial equipment with embedded sensors, connected consumer terminals) and service-oriented extensions (remote operation and maintenance, predictive maintenance, subscription-based business models) have become new growth points for enterprises. Enterprises are transforming from the traditional model of "selling products" to "selling solutions", and migrating to the higher end of the global value chain, such as R&D and design, and system integration. This transformation not only improves gross margins, but also enhances market competitiveness and customer stickiness.

5.2.4. Market responsiveness leapfrogging

With a demand insight system based on big data on consumer behaviour, companies can accurately match consumption preferences in different regions, supporting modular customisation of product features and globalised market segmentation. This capability enables enterprises to respond quickly to market changes and increase brand penetration and customer loyalty. Through digital transformation, enterprises can better meet the individual needs of customers and enhance market competitiveness.

5.2.5. Accelerated Construction of Innovation Ecology

Digital transformation has accelerated the construction of an innovation ecosystem. The industrial Internet platform promotes in-depth collaboration between industry, academia, research and application, and enterprises integrate external innovation resources through open API interfaces and the construction of joint laboratories, which shortens the technology transformation cycle by 50 per cent. This kind of open innovation system not only improves the innovation ability of enterprises, but also forms the development mode of "independent control of core ability + flexible call of external resources", which provides strong support for enterprises to win competitive advantages in the global market.

5.3. Coping Strategies

In order to meet the challenges and seize the opportunities of digital transformation, enterprises need to develop systematic response strategies. These strategies provide support from various aspects, such as technology deployment,

talent matrix, data governance, organisational agility capability, industry chain collaborative innovation and policy and financial tools, to help enterprises break through transformation bottlenecks and achieve sustainable development.

5.3.1. Gradient technology deployment to optimise resource allocation efficiency

Enterprises should establish a phased implementation path of "pilot verification - scenario expansion - global integration". Firstly, they should prioritise the pilot implementation of digital twin and edge computing technologies in high-value segments (e.g. bottleneck process intelligence, quality inspection automation). Through the Minimum Viable Product (MVP) to verify the feasibility of the technology and return on investment, and then gradually replicated to the whole industry chain. This gradient approach can effectively reduce the risk of one-time investment, optimise resource allocation, and ensure the sustainability of the enterprise's investment in technology.

5.3.2. Building a three-dimensional talent matrix to break the contradiction between supply and demand of skills

Enterprises should implement the strategy of "internal training and external attraction + ecological co-education". They should establish "industrial digitalisation" modern industrial colleges with universities to train talents in short supply in industrial software and data modelling. Establish a "technical mentor system" and introduce external expert teams to carry out practical project training to improve the practical ability of employees. The company has developed a digital competence assessment system and promoted the participation of all employees in micro-certification (e.g. Python data analysis, industrial Internet platform operation), so as to create a three-tiered talent structure, with management knowing strategy, technical layer being proficient in research and development, and executive layer being good at application. Through the multi-level talent training system, enterprises can effectively solve the contradiction between supply and demand of skills and provide a solid talent guarantee for digital transformation.

5.3.3. Strengthen data compliance governance and build a strong security protection system

Enterprises should build a three-in-one data governance framework of "technology + management + compliance". At the technical level, adopt zero-trust architecture (ZTA), dynamic encryption technology and distributed ledger storage to realise security protection for the whole chain of data collection, transmission and application. At the management level, a data classification system is established to clarify the rights and responsibilities of each business unit and ensure the reasonable use of data. At the compliance level, it actively participates in the formulation of international data standards such as ISO/IEC 31700, and solves the problem of cross-border data "availability and invisibility" through privacy computing technology to avoid geopolitical risks. Through all-round data governance, enterprises can build a strong security protection system to ensure data security and compliance.

5.3.4. Reinventing organisational agility capabilities to activate endogenous dynamics of transformation

Enterprises should promote the change of "platform organisation", break down the traditional departmental barriers, set up a cross-functional transformation team under

the direct management of the Chief Digital Officer (CDO), and give it priority in resource scheduling and decision-making. Constructed a new structure of "front-end agile operation + back-end resource empowerment", and realised rapid reconstruction of business processes through a low-code platform. Introducing management tools such as OKR (Objectives and Key Results), establishing a data-driven performance appraisal system, and fostering an organisational culture of "Trial and Error, Iteration and Innovation". Through these measures, enterprises can reshape the agility of their organisations and activate the endogenous momentum of digital transformation.

5.3.5. Deepening industry chain collaborative innovation and building a digital ecological community

Enterprises should play the leading role of "chain master" enterprises, and jointly build industry-level industrial Internet platforms with upstream and downstream enterprises to share production capacity data, supply chain mapping, and R&D resources, so as to realise the digitalisation of the whole chain of order collaboration, inventory sharing, and quality tracing. Promote the development of lightweight solutions for small and medium-sized enterprises focusing on niche scenarios, forming an ecological synergistic pattern of "big enterprises standing on top of the sky and small enterprises specialising in speciality and innovation". Through the collaborative innovation of the industrial chain, enterprises can improve the overall transformation efficiency, build a digital eco-community, and achieve mutual benefits and win-win results.

5.3.6. Make good use of policy and financial tools to strengthen the protection of transformation factors

Enterprises should establish a "policy + capital + technology" linkage mechanism, accurately docking the government's digital transformation special subsidies, R & D expenses plus deduction and other policy dividends, and strive for "lighthouse factories", "intelligent manufacturing maturity assessment" and other pilot qualifications. We also strive for the pilot qualification of "Lighthouse Factory" and "Intelligent Manufacturing Maturity Assessment". We have cooperated with industrial funds and technology banks to develop financial products such as "transformation loan", "equipment financial leasing + digital services", and explored REITs mode to revitalise stock assets. Through green credit, we support the application of energy-saving and carbon-reducing technologies, and turn ESG (environmental, social and governance) performance into transformation competitiveness. Through these policy and financial tools, enterprises can strengthen the elemental guarantee for transformation and provide strong support for digital transformation.

6. Conclusions and Suggestions

6.1. Conclusions

Through empirical analyses and theoretical discussions, this study provides an in-depth study of the impact of digital transformation of listed Chinese manufacturing companies on their global value chain position enhancement. It is found that digital transformation is not only a key strategy for manufacturing firms to enhance their competitiveness, but also an important driving force for them to climb up the global value chain. Specifically, digital transformation significantly improves production efficiency, product quality and market responsiveness through optimising production processes, enhancing innovation capabilities and strengthening supply

chain synergies, thereby promoting the migration of enterprises to higher value-added segments in GVCs.

6.2. Suggestions

6.2.1. Government level

First, the Government should strengthen policy guidance, formulate and improve relevant policies, and encourage manufacturing enterprises to accelerate the pace of digital transformation. According to the actual situation of the introduction of tax incentives, the digital transformation of enterprises related to the purchase of equipment, R & D investment, software purchases, etc. to give tax deductions or credits; to give financial subsidies to the digital transformation of enterprises, the establishment of a special enterprise digital transformation fund, to provide low-interest or interest-free loans for the enterprise to support the construction and operation of its digital project; to encourage financial institutions to launch a support for digital transformation of the enterprise's special credit products , increasing financial support for digital transformation.

Secondly, improve the construction of digital infrastructure, increase investment in network infrastructure, data centres and other digital infrastructure, and provide good basic conditions for the digital transformation of manufacturing enterprises. Actively promote the development of industrial Internet , increase support for the construction of industrial Internet platforms, encourage enterprises to go to the cloud on the platform, to achieve equipment interconnection, production data sharing and business synergy; promote the construction of the industrial Internet logo resolution system, and promote interconnectivity and information sharing between enterprises upstream and downstream of the industrial chain. The government mainly promotes the collaborative transformation of the industrial chain, supports chain master enterprises to drive, encourages chain master enterprises and leading enterprises to open up digital system interfaces, promotes small and medium-sized enterprises upstream and downstream of the supply chain to implement standardised digital transformation, and promotes small and medium-sized enterprises to integrate into the supply chain of large enterprises, and strengthens their ability to support them in the supply chain.

At the same time, the government should strengthen the cultivation and introduction of talents to improve the innovation ability and competitiveness of China's manufacturing enterprises in the field of digitalisation. It should formulate a digital talent training plan, strengthen the construction of digital-related majors in colleges and vocational schools, adjust the curriculum, increase the proportion of practical teaching, and cultivate professional and technical talents and composite talents who can adapt to the needs of digital transformation of enterprises.

6.2.2. Enterprise level

Firstly, enterprises should first accurately grasp the direction of transformation, take into account their own market positioning, business characteristics and development strategy, and clearly define the objectives of digital transformation, such as improving production efficiency, reducing costs, optimising supply chain management, enhancing customer experience, etc., so as to point out the direction for the transformation work. Based on the objectives, a detailed transformation roadmap covering the short, medium and long term should be formulated, with key tasks and milestones at each stage clearly defined and regularly

assessed and adjusted according to market and technology dynamics.

Secondly, the layout of digital infrastructure should be optimised. To make efficient use of global network resources, enterprises should actively make use of high-speed broadband networks covering the whole world to optimise cross-border business communications and data transmission, reduce latency and lag, and ensure smooth information flow. At the same time, they should make use of the elastic expansion advantages of cloud data centres to obtain storage and computing resources on demand, guarantee stable operation during business peaks, avoid the high costs and long cycles of local data centre construction, rapidly deploy services and timely adjust resource allocation, and achieve cost reduction and efficiency.

Thirdly, the importance of intellectual capital as a vehicle for innovation should be reinforced. If the enhancement of an enterprise's position in the global value chain is a reflection of the results of its innovation activities, it is all the more important for enterprises to increase their investment in R&D, continuously increase their capital investment in R&D, set up overseas R&D centres or innovation laboratories, collaborate with international scientific research institutes, attract outstanding scientific research talents from all over the world, carry out research on cutting-edge technologies, accelerate the research and development and promotion of new products and processes, and enhance the position of the enterprise in the global value chain. On this basis, enterprises should pay attention to the protection of intellectual property rights, establish a sound intellectual property management system, apply for patents, trademarks and other intellectual property protection for their innovations in a timely manner, and at the same time respect the intellectual property rights of others to avoid infringement disputes. They should actively participate in the formulation of international intellectual property rules, enhance their influence and discourse power in the field of international intellectual property rights, and provide a strong guarantee for the global promotion of innovative achievements.

6.3. Research Limitations and Future Research Directions

This study has some limitations in theory and practice. In theory, the relationship between digital transformation and GVC status enhancement needs to be further explored in depth with regard to its underlying mechanisms and transmission paths; in practice, due to the limitations of data acquisition, this study has not been able to conduct a more comprehensive and in-depth case study on the digital transformation of manufacturing enterprises. Future research can focus on the following directions:

6.3.1. Deepening theoretical research

Further explore the deep-level mechanism of digital transformation on the enhancement of enterprises' global value chain status, and construct a more complete theoretical

framework. For example, the impact of digital transformation on enterprise competitiveness and global value chain status can be analysed from multiple angles by combining multidisciplinary theories such as industrial economics and innovation economics.

6.3.2. Expanding empirical research

Expand the sample scope, collect data from more manufacturing enterprises, and conduct empirical analyses using a variety of research methods to validate and enrich the conclusions of this study. At the same time, manufacturing enterprises of different industries and sizes can be categorised to explore in depth the heterogeneous impact of digital transformation in different groups of enterprises.

6.3.3. Strengthening international co-operation and comparative research

With the deepening of globalisation, the digital transformation of manufacturing enterprises and the upgrading of their position in the global value chain are increasingly influenced by the international environment. Future research can strengthen international cooperation and comparative research, analyse the lessons learned from the digital transformation of manufacturing enterprises in different countries and regions, and provide a more international perspective for the digital transformation of China's manufacturing enterprises.

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