

# A Review of Research on Digital Transformation Capabilities in Manufacturing

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**Abstract:** As the main body of the national economy, manufacturing industry realizes digital transformation which is of great significance for China's economic development. Most of the current popular research on the topic of digital transformation focuses on the transformation path, transformation drivers, transformation influencing factors, transformation mode and maturity evaluation. Taking the digital transformation capability of manufacturing enterprises as the research object, this paper combs through the connotation of digital transformation, studies related to the digital transformation of manufacturing enterprises, and studies related to the digital transformation capability and its evaluation, aiming to provide directional guidance for future academic research.

**Keywords:** Digital transformation, Transformation capability evaluation, Manufacturing companies, Research review.

## 1. Introduction

With the arrival of the digital era, the continuous maturity and wide application of digital technology is undoubtedly an important challenge that cannot be avoided in the reform process for traditional enterprises, but it also brings new opportunities for the innovative development of traditional enterprises. Under the wave of the digital economy, more and more enterprises have opened the road of digital transformation.

As early as 2013, Germany put forward the concept of the fourth industrial revolution - "Industry 4.0", which emphasizes the use of information and Internet of Things systems, creating new business models and production methods, transforming the manufacturing industry to intelligent, promoting industrial change, and realizing the intelligent era with intelligent manufacturing as the main focus [1]. In 2015, China also introduced the 10-year strategic plan "Made in China 2025". As a result, China officially opened the first year of the fourth industrial revolution based on digital technology in 2015, setting off the development trend of the deep integration of traditional industry with a new generation of information technology [2]. In 2017, the digital economy was formally included in China's Government Work Report for the first time, marking the rise of the digital economy as a national strategy and implying that the development of the digital economy will become the main path for China's innovation and growth. And the digital transformation of enterprises is an important way to promote the development of digital economy in China [3]. The strategy of developing a digital economy and building a digital China emphasizes empowering traditional enterprises, including small and medium-sized enterprises, with digital networking and intelligence, and promoting enterprises to realize the deep integration of the digital economy and the real economy through digital transformation. A series of strategic plans such as "Made in China 2025", "Internet Plus", big data, artificial intelligence and so on have become important initiatives for China to realize a new round of science and technology and industrial revolution.

In the face of the general trend of digitalization strategy, a

part of the industry and enterprises have been in the forefront, taking the lead in digital transformation, especially in the industrial field of China's enterprises digital transformation level and the gap between developed countries is shrinking. In the industrial field, GE of the United States has taken the lead in promoting the development of the industrial Internet, Siemens of Germany has launched the MindSphere ecosystem, ABB of Switzerland has launched the ABB Ability cloud service platform, and Haier has become the world's largest home appliance maker through digitalization transformation, etc. In the retail sector, the rapid rise of online retailers such as Alibaba and Amazon has led to the bankruptcy of some traditional retailers, while brick-and-mortar retailers such as Yintai, Tianhong, and BBK have survived through digital transformation. Nonetheless, enterprises in China are still facing practical problems such as unclear digital strategies, missing transformation methods, insufficient transformation capabilities, and missing transformation power mechanisms, and it can be said that very few enterprises are still realizing digital transformation in the true sense of the word. Accenture's newly released "2023 China Enterprise Digital Transformation Index" shows that only 17% of China's enterprises will have significant digital transformation effects in 2022. Only a small percentage of Chinese enterprises will be able to fully deepen their transformation strategies and prepare for the next phase of growth, and only 2% of the surveyed enterprises will reshape their businesses and functions by building digital core competencies. Meanwhile, 46% of Chinese companies surveyed plan to increase investment in artificial intelligence and automation.

The manufacturing industry is the main body of the national economy, which is the foundation of the country, the tool for the development of the country, and the basis for the strengthening of the country. As a key industry for the implementation of China's digital transformation strategy, in June 2023, the state issued a notice on the pilot work of SMEs' digital transformation cities, which tilts the pilot key industry areas to SMEs in manufacturing industries, such as general and special equipment manufacturing, automobile manufacturing, and so on, from the perspective of the regional strategic development plan and industrial orientation. Digital

transformation as an opportunity to improve the core competitiveness of small and medium-sized enterprises, stimulate the emergence of more specialized, special and new small and medium-sized enterprises, and promote the high-quality development of the real economy. Therefore, exploring the evaluation system of the digital transformation capability of manufacturing enterprises and evaluating the digital transformation capability of manufacturing enterprises can enable them to scientifically assess their own digital transformation capability, discover problems in the process of digital transformation in a timely manner, and improve their digital transformation capability.

## 2. Study on the Connotation of Digital Transformation

Many scholars consider digital technology to be the beginning and core of digital transformation, turning their attention to the integration of technology within the enterprise, bringing digital transformation to the enterprise level, and elaborating on the changes that digitalization has made to the enterprise. For example, Canadian scholar Gregory Vial (2019) [4] proposes that digital transformation is a process in which an organization triggers a strategic response by using the changes brought about by digital technology to change the value creation path that it used to rely on and implement structural changes, while managing the factors that affect the outcome of the transformation for better or worse, such as structural changes and organizational barriers, in this process. Jiao and Zhang (2020) [5] argued that digitalization is the realization of interconnectivity within a manufacturing enterprise, while digital transformation is based on digitalization, it is a multifaceted phenomenon, an organization can easily complete a series of digital projects, but there is no guarantee that it will inevitably achieve digital transformation. Mina et al. (2020) [6] Define digital transformation as a change in business processes, culture, and organization driven by digital technology to meet market needs. Lauri et al. (2021) [7] distinguish digital transformation from IT, arguing that digital transformation activities use digital technologies to (re)define an organization's value proposition and involve the emergence of a new organizational identity, whereas IT-driven organizational transformation activities simply use digital technologies to support the value proposition and enhance the existing organizational identity. Qian and He (2021) [8] argued that enterprise digital transformation uses digital technology to reshape organizational structure, business processes, business models, and strategic thinking by using data as a core driving element to achieve strong connectivity and value co-creation with enterprise stakeholders in order to improve enterprise competitiveness. Wu et al. (2021) [9] From the three elements of digital technology, transformation scope and transformation result, digital transformation is defined as a process in which enterprises reconfigure their products and services, business processes, organizational structures, business models and cooperation models through a combination of information, computing, communication and connectivity technologies with the aim of designing their business activities more efficiently, which can help them to create and acquire more value. Qi et al. (2021) [10] consider enterprise digital transformation as a "smart link" that will lead to changes in the business processes and production models of the enterprise. Sascha et al. (2022) [11] suggest that

the focus of the definition of digital transformation varies depending on the use of different new technologies, such as improvements in processes, operations, customer relationships and performance, or the creation of new business models, or the impact on a number of actors and environments. Ying et al. (2022) [12], based on an institutional theory perspective, view the digital transformation of manufacturing enterprises as a process of "legitimacy construction and expansion" from the old institutional logic to the new one.

## 3. Study on the Digital Transformation of the Manufacturing Industry

Early research focused on qualitative research on digital transformation, generally from the development of digital transformation status quo, characteristics, problems and countermeasures. Later studies are gradually enriched, and more scholars conduct empirical research on the influencing factors, mechanisms and benefits of enterprise digital transformation. Vogelsang (2018) [13] Empirical analysis based on the IS model found that the factors for the success of digital transformation in manufacturing companies are mainly in the three aspects of technology, organization and environment. Vial (2019) [4] classified digital transformation paths into business enhancement aspects of combining products and services and simplifying organizational structure aspects from the perspective of business operations. Kohtamäki et al. (2020) [14] pointed out that digital inputs need to be able to bring value to consumers in order to get a certain benefit, and the perfect integration of digitalization and servitization is the only way for enterprises to innovate and upgrade and get value, and at the same time, it can achieve the effect of "1+1>2". Chi et al. (2020) [15] from the perspective of digital empowerment to build a theoretical model, empirical analysis concludes that small and medium-sized manufacturing enterprises can achieve lasting innovation through digital empowerment, solve the problems of lack of resources and insufficient depth of resource integration, and improve their new product development performance by influencing the dual capabilities of research and development through digital transformation. Jin et al. (2020) [16] used the method of rooted theory, and found that government regulation, organizational structure, executive talent, internal construction of information systems, the enterprise's own production technology capabilities, external industry and market changes, and cooperative resources are seven important influencing factors in the process of digital transformation of the manufacturing industry. Li and Liang (2020) [17] proposed that the enterprise transformation path contains the following four aspects: first, based on the scale and stage of development of the enterprise to implement a differentiated transformation model, second, the implementation of a business model with the core of consumer empowerment, third, to create an agile organization for the purpose of improving management efficiency, and fourth, the focus of asset management is shifted from physical assets to data assets. Matteo et al. (2021) [18] proposed to improve manufacturing productivity by means of increasing innovation investment and using new equipment and technology, and ultimately enhance the ability of digital transformation and upgrading of manufacturing industry. Porfírio et al. (2021) [19] used the FSQCA methodology, and conducted a study on the collected questionnaire data and

proposed that enterprise characteristics and management characteristics are the key prerequisites for realizing digital transformation. Carlos et al. (2021) [20] pointed out that in the traditional automobile manufacturing industry, automobile manufacturers, service providers, as well as the board of directors of multinational corporations and the government have a greater influence on their digital transformation, and analyzed using the fuzzy set qualitative comparative analysis method to conclude that investing in corporate infrastructure projects, innovation activities, are the fundamental drivers of digital transformation. Zhao (2021) [21] proposed from an empirical point of view that digital development indirectly promotes the service-oriented transformation of manufacturing enterprises through the mechanism of improving the innovation ability of enterprises and optimizing the structure of human capital, which in turn improves the economic efficiency of enterprises, achieves value-added at both ends of the value chain, and boosts the high-quality development of enterprises. Wang and Jiang (2022) [22] found that human capital and economic environment play a significant role in promoting the digital transformation of manufacturing industry, while capital investment and foreign trade environment play a negative role. Chi et al. (2022) [23] classified digital transformation into manufacturing process digitization and business model digitization, and found that both promote the improvement of corporate financial performance, where the agility of organizational change catalyzes this promotion. Fan and Wang (2022) [24] conducted a study on the data of A-share listed automobile manufacturing companies from 2013-2019 and found that digital transformation increases companies' investment in R&D personnel, which has a positive impact on corporate innovation.

## **4. Digital Transformation Capability Study**

### **4.1. Research on Digital Transformation Capabilities from Different Perspectives**

Under the trend of digital transformation, scholars in the field of capability theory research have begun to pay attention to the issue of digital transformation capabilities. Compared with IT capabilities that focus on optimizing business processes, digital transformation capabilities have a significant role in driving digital transformation and business model innovation in enterprises [25]. Under different research perspectives, the focus and scope of enterprise digital transformation capabilities are different, and the relevant research perspectives mostly focus on the resource-based view, the technology application level, and the dynamic capability theory.

Under the resource base view perspective, resources with scarcity due to the application of digital technology become important digital transformation capabilities. Lenka et al. (2017) [26] argued that data, as an important production factor in the digital era, cannot be directly applied to the production and operation activities of enterprises by itself, and only through the application of digital technology in various value chain links can fragmented and multiple data resources be upgraded to resources with scarce value. In a related study, Ritter and Pedersen (2020) [27] start from the conditions of enterprise digitization and identify data, licensing, and analytics as the key dimensions that constitute

an enterprise's overall digital transformation capability.

Under the perspective of technology application, digital transformation capabilities are expressed as digital technology-driven capabilities, i.e., the results of the application of digital technology in various parts of the enterprise value chain and in operation and management. Eric and Richard (2019) [28] defined the connotation of digital technology capabilities in their study of business models and strategies of digital enterprises, and regarded digital technology capabilities as an important digital transformation capability that promotes enterprise business model innovation and organizational change.

Some other scholars have studied from the perspective of dynamic capabilities. For example, Yeow et al. (2018) [29] argue that even if an organization successfully "transforms" in its current environment, it will still face the need to transform when the environment changes again. Li and Sun (2019) [30] argue that the ability to interact collaboratively with suppliers, intermediaries, and other stakeholders becomes an important component of digital transformation capabilities. Zhou and Sun (2020) [31] proposed the concept of "digital dynamic capabilities", extracted the development stages of business incubation platforms as energy storage, nurturing, and empowerment through case studies, and explained the digital dynamic capabilities corresponding to each stage, which are digital organizational capabilities, digital operational capabilities, and digital co-creation capabilities, respectively. Abbate et al. (2021) [32] conducted a study from the perspective of dynamic capabilities theory to explore the capabilities required for co-innovation in open innovation digital platforms, and found that the capabilities of sensing, capturing, and integrating and transforming play an important role in sustaining co-creation and exploring new values. Ji et al. (2022) [33] summarized four dimensions of digital transformation capabilities of manufacturing enterprises by applying the rooted theory, considering the characteristics of the manufacturing industry, and combining the dynamic capability perspective, which are digital foundation capability, digital analysis capability, digital application capability, and digital output capability. Hou and Gao (2022) [34] argued that digital transformation capability is a dynamic capability that enhances the competitive advantage of enterprises, and proposed that digital transformation information integration capability and digital transformation technology application capability are important elements of digital transformation capability, which play an important role in promoting the innovation performance of enterprises.

### **4.2. Evaluation Study of Digital Transformation Capabilities**

Some scholars, on the basis of dividing digital transformation capability into various dimensions from different perspectives and establishing an evaluation system, have also used various evaluation methods to evaluate the digital transformation capability of different enterprises. For example, Chen et al. (2020) [35] believe that data is the core of digital transformation of manufacturing enterprises, divide the transformation capability into three dimensions: technical change capability, management change capability, and organizational change capability, and use hierarchical analysis and case studies to evaluate the capability of digital transformation of manufacturing industry. Based on the two

dimensions of output capacity and input capacity, Sun (2020)[36] comprehensively evaluates the intelligent transformation ability of express delivery enterprises through the mutation level method. Li et al. (2022) [37] Based on the input and output perspective, we construct the evaluation system of digital innovation ability of manufacturing enterprises from five dimensions of digital innovation patent output, talent reserve, capital acquisition, resource integration, and economic foundation, and empirically evaluate 169 manufacturing enterprises by using the random forest algorithm and mutation level method. Wang and He (2022) [38] Construct the evaluation system of digital transformation of manufacturing industry, adopt CRIITIC-entropy value method combined weight model, evaluate the digital transformation of 64 domestic automobile manufacturing enterprises, and believe that the development of digital transformation of China's automobile manufacturing enterprises is in good condition, and digital transformation will improve the performance of the enterprise by reducing the rate of operating costs, the rate of management expenses and the rate of sales expenses. Based on the capability maturity model, Li et al. (2023) [39] constructed the evaluation system of digital management capability of production equipment from the two dimensions of production equipment composition form and its life cycle, and used entropy method and cloud model to conduct empirical quantitative evaluation.

Some other scholars have explored the mediating role of digital transformation capabilities through empirical studies. Yi et al. (2021) [40] taking Internet platform enterprises as the research object, found through empirical research on more than 300 Internet enterprises that digital transformation capability has a mediating effect in the influence of organizational inertia on the business model innovation of platform enterprises. Zhu et al. (2022) [41] used questionnaires from more than 200 manufacturing enterprises as data samples, and found that manufacturing enterprises can significantly promote the transformation of products and services on the basis of actively implementing digital strategies and having a high level of digital transformation capabilities. Hou and Gao (2022) [34] took 206 equipment manufacturing enterprises as the research object, and found through empirical research that digital transformation information integration capability has a mediating effect on the relationship between enterprise network structure and innovation performance. Fan and Wu (2022) [42] collected provincial sample data from 2014 to 2017, and proved through empirical research that digital transformation capability has a mediating effect in the impact of new infrastructure on total factor productivity.

## 5. Conclusions

This paper provides an overview of the current state of domestic and international research in the following three points.

In terms of the research on the connotation of digital transformation: scholars at home and abroad describe the connotation of digital transformation through different elements such as tools, scope, process and results, etc. It is not difficult to see that digital technology is regarded as the core of digital transformation, including big data, the Internet, the Internet of Things and so on. However, digital transformation is not carried out from a single perspective of technology, but

also includes a combination of multiple factors such as organizational change, innovation drive and value creation.

In the research of digital transformation of manufacturing industry: relevant scholars at home and abroad study the influencing factors and realization path of enterprise digital transformation by constructing theoretical models and empirical analysis, and find that digital transformation enhances the economic benefits and value of enterprises by influencing the R&D capability and innovation capability of manufacturing enterprises, etc., i.e., digital transformation is realized through the realization path of indirect conduction mechanism.

In the research on digital transformation capability: in the current research, scholars do not clearly distinguish between digital capability and digital transformation capability. Scholars at home and abroad have studied the dimensions of digital transformation capability and divided it from different perspectives, such as dynamic capability perspective, technology application perspective, input-output perspective, etc., and based on this, different evaluation tools are used to construct models to evaluate them. Some other scholars have also empirically studied the mediating role of digital transformation capabilities.

Most of the current research by scholars on the current popular theme of digital transformation focuses on the transformation path, transformation drivers, transformation influencing factors, transformation mode and maturity evaluation. From a comprehensive point of view, in recent years, academics have actively carried out research on enterprise digital transformation, which can be divided into six aspects from the theoretical framework: analyzing the influencing factors driving enterprise digital transformation from the perspective of motivation, analyzing the process of enterprise digital transformation in different industries from the perspective of process, realizing the path and mechanism of the research, analyzing the results of enterprise digital transformation from the perspective of results, exploring the strategy formulation and implementation of enterprise digital transformation from the strategic perspective, and analyzing the role of digital technology in the development and implementation of digital transformation from the perspective of technology. From the outcome perspective, we will analyze the results of enterprise digital transformation; from the strategic perspective, we will discuss the strategy formulation and implementation of enterprise digital transformation; from the technological perspective, we will analyze the application of digital technology in the process of digital transformation; and from the evaluation perspective, we will discuss the capability assessment and maturity assessment of enterprise digital transformation.

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