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A Review of the Research on the Improvement of Total Factor Productivity of Chinese Enterprises by Digital Transformation

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Abstract. Driven by the digital wave, the improvement of total factor productivity (TFP) of enterprises has become an important indicator to measure their market competitiveness and sustainable development ability. This paper aims to explore how digital transformation affects the TFP of Chinese enterprises. Through a comprehensive review of the existing literature, this paper uses the PRISMA method to comprehensively identify and screen the relevant academic journal literature published between 2004 and 2024, and finally analyzes 186 articles. The study found that digital transformation has a positive impact on corporate TFP by reducing operating costs, improving production efficiency, and enhancing economies of scale. As mediating variables, innovation performance and human capital structure play an important role between digital transformation and TFP improvement. On the whole, this paper not only provides theoretical guidance and practical suggestions for the digital transformation of enterprises, but also provides a new perspective for academic research.

Keywords. Digital transformation; total factor productivity; research review

1. Introduction

Driven by globalization and technological innovation, enterprises are facing unprecedented challenges and opportunities. The rapid development of information technology, especially the wide application of emerging technologies such as cloud computing, big data and artificial intelligence, provides a new path for enterprises to transform and upgrade. Among them, digital transformation has become one of the important directions of enterprise transformation. As an important indicator to measure the comprehensive production efficiency of enterprises, total factor productivity has also received extensive attention from the academic community.

Digital transformation refers to the process in which enterprises use digital technology to comprehensively transform and improve business processes, organizational structure, corporate culture to achieve optimization and upgrading in terms of production efficiency, market competitiveness, and sustainable development[1].

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The essence of this transformation process lies in the transformation from 'industrial management' to 'digital management'[2]. It requires enterprises to abandon the inertial thinking of traditional management mode and reshape the management logic to bring about the innovation of management mode[3]. Total factor productivity (TFP) is a key economic indicator to measure the comprehensive production efficiency of enterprises[4]. It covers all kinds of tangible resources invested by enterprises in the production process, including human, material and financial resources. The improvement of TFP reflects the ability of enterprises to increase output by optimizing resource allocation, improving technology application and enhancing organizational efficiency without increasing additional input[5]. Therefore, the growth of TFP is usually regarded as the result of technological progress and production efficiency improvement, which is an important manifestation of enterprise innovation and competitiveness[6].

Academia and industry generally believe that digital transformation has a significant positive effect on improving enterprise TFP by optimizing business processes, enhancing organizational flexibility and innovation capabilities. This review aims to systematically sort out and analyze the correlation mechanism and its impact path between digital transformation and enterprise TFP improvement, and put forward suggestions for future research directions.

2. Theoretical background

2.1. Resource-based view

Resource-based view is a core theory in the field of strategic management, which emphasizes the role of internal resources and capabilities in creating competitive advantage. In the context of digital transformation, enterprises build competitive advantages that are difficult to imitate by integrating and optimizing their digital resources, such as artificial intelligence and big data analysis. These digital resources not only improve the operational efficiency of enterprises, but also enhance their innovation ability, thus affecting the TFP of enterprises. Zhao emphasized the role of digital resources in improving the production efficiency of enterprises from the perspective of resource base[7].

2.2. Dynamic capability theory

Dynamic capability theory focuses on how enterprises adapt to the rapidly changing external environment through dynamic capabilities. In the process of digital transformation, enterprises need to develop new capabilities to adapt to the continuous advancement of digital technology and effectively respond to market changes. These dynamic capabilities enable enterprises to continuously update their resource base, thereby enhancing TFP. Wang emphasizes the importance of dynamic capabilities in the digital transformation of enterprises, and points out that enterprises can promote internal technological upgrading and structural optimization through digital transformation[8].

3. Research method

3.1. Data sources

This paper adopts the PRISMA system review method. Systematic review is a research method that comprehensively identifies relevant academic literature based on specific research questions. This paper retrieves and screens the literature on 'digital transformation and TFP' in the domestic core database CNKI, and sets the subject word as 'digital + transformation' and 'Total factor productivity' in the advanced retrieval. The search database is set as an academic journal, the literature source is set as a core journal, and the discipline is set as enterprise economy and management. The time span is 2004-2024. The specific process is shown in Figure 1.

3.2. Literature inclusion and exclusion criteria

In order to better sort out the existing articles, import them into NoteExpress software and delete duplicate documents. According to the research purpose, the literature that does not meet the requirements is removed, and the full text of the literature that meets the requirements is downloaded. The final literature was determined according to the inclusion and exclusion criteria.

The inclusion criteria of this paper are as follows: ①The content of the literature directly involves the relationship between digital transformation and TFP;②Articles that give priority to core journals;③Articles that include intermediary mechanisms or influence paths. The exclusion criteria for this article are:①literature from non-full-text types such as conference abstracts, conference papers, etc.②literature with poor research design, unreliable data, or unclear conclusions.

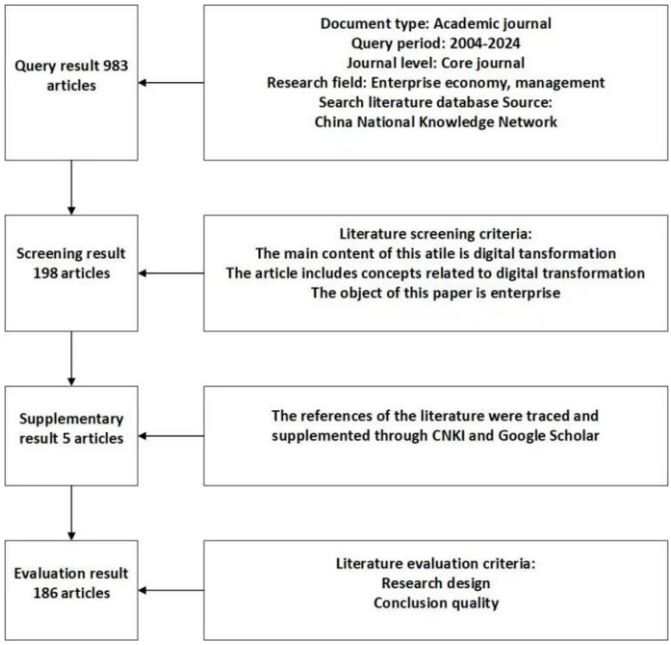

Figure1. Literature screening process

3.3. Search results

There were 1563 articles in the initial query results of this study. After deduplication, a total of 983 articles were retrieved and set as the initial sample of this study. According to the inclusion criteria, 198 literatures were screened out, and 5 eligible studies were further supplemented in the references cited in these literatures, bringing the total number to 203. Finally, according to the exclusion criteria, 17 articles were deleted, and 186 articles were finally identified for subsequent analysis.

4.The effect of digital transformation on TFP

Digital transformation has become the core of enterprise strategy, and its impact on total factor productivity is the focus of both academia and industry. By summarizing the existing literature, this study draws the following two findings. Firstly, most studies have shown that digital transformation can significantly improve the intelligence level and process efficiency of enterprises and reduce costs by introducing cutting-edge technologies such as artificial intelligence, blockchain, cloud computing and big data, thus having a positive impact on total factor productivity. Zhao shows that there is a positive correlation between digitization and total factor productivity[7]. In addition, Wan pointed out from the perspective of regional economic development that the effect of digital transformation on TFP is more significant in areas with perfect infrastructure. However, some studies have pointed out that digital transformation may cause inequality among different regions, industries or enterprises, and may bring challenges to traditional industries. As Liu said, if the industrial structure is not adjusted properly, it may have a negative impact on TFP[9].

Therefore, the impact of digital transformation on total factor productivity is complex and multifaceted, both positive and negative. However, this paper believes that digital transformation is the cornerstone of the innovation model and system of enterprises, and it is also the key way to promote the digital and intelligent development of traditional industries. It injects new vitality into traditional industries through R&D innovation, so it positively affects total factor productivity. Regardless of enterprise ownership or life cycle stage, digital transformation helps to improve total factor productivity and becomes an important way for sustainable development.

5. The mediating mechanism of digital transformation affecting TFP

According to reading relevant literature, using content analysis and systematic review method, it is concluded that there are intermediary variables such as human capital structure, innovation performance, green innovation, corporate governance model and labor skill structure in the process of the impact of digital transformation on the TFP of enterprises. This paper selects the first two to do a detailed review.

5.1. The human capital structure as an intermediary affects TFP.

Human capital structure plays a key intermediary role in the impact of digital transformation on total factor productivity. Through digital transformation, enterprises

optimize and rationally allocate human capital structure, cultivate and promote employees' personal development, enhance the overall competitiveness of enterprises, and then promote the improvement of total factor productivity of enterprises.

Firstly, digital transformation helps to optimize the structure of human capital. First, digital transformation can promote the optimization and adaptive change of human capital structure. Yu proposed that digital transformation can promote the adjustment of human capital structure to a higher level[10]. Second, digital transformation can increase the demand for highly skilled labor. Xiao points out that the technological innovation in production caused by digital transformation reduces the dependence on low-skilled labor, thus optimizing the allocation of human capital[11]. Secondly, the human capital structure can promote the total factor productivity of enterprises. Through the research of scholars, it can be found that the improvement of the proportion of staff quality and high-skilled talents can effectively improve the total factor productivity of enterprises. The research of Zhao proves that the advanced level of human capital structure is an important medium to promote the improvement of total labor productivity[12]. At the same time, different types of human capital play different roles in enterprises and jointly promote the improvement of total factor productivity.

In summary, in the process of digital transformation, optimizing human capital structure can not only improve the production efficiency and work quality of employees but also further promote the improvement of total factor productivity by promoting internal collaboration and innovation. Guo put the digital economy, the upgrading of human capital structure, and the total factor productivity of enterprises in the same analytical framework and deeply analyzed how the digital economy and the upgrading of human capital structure affect the total factor productivity of enterprises from a theoretical perspective[13]. In addition, optimizing human capital structure can also indirectly improve total factor productivity by acting on the market expansion and resource allocation of enterprises.

5.2. Innovation performance as an intermediary to influence TFP.

As one of the important factors in improving the total productivity of enterprises, innovation performance also plays an intermediary role in the digital transformation process. In this process, innovation performance is not only a direct result of digital transformation, but also a key factor to promote the improvement of total factor productivity.

First of all, digital transformation can improve enterprise innovation performance. First, digital transformation can strengthen the ability of enterprise resource integration, so as to improve the efficiency of enterprise innovation. Zhang demonstrated from three aspects : digital transformation reduces the cost of enterprise information acquisition, digital transformation improves the efficiency of enterprise innovation, and digital transformation helps enterprises determine the direction of innovation, thus effectively promoting enterprise innovation[14]. Second, digital transformation is conducive to optimizing the R&D process, rationally allocating resources, and thus improving R&D efficiency and innovation capabilities. Yu found that the digital economy can significantly enhance the innovation performance of enterprises, and this enhancement effect is different among different scales and industries[15]. Fang believed that digital transformation can help enterprises achieve R&D internationalization, control R&D costs, and enhance innovation performance[16]. Furthermore, the improvement of innovation performance can promote the improvement of total factor productivity of

enterprises. The improvement of innovation performance has significantly improved the total factor productivity of enterprises by accelerating technological progress, optimizing resource allocation, and strengthening the dynamic capabilities of enterprises. On the one hand, technological innovation promotes the wide application of digital technology by reducing the dependence on traditional production factors such as labor and capital, thereby improving the total factor productivity of enterprises; on the other hand, the protection of innovative patents can bring unique competitive advantages to enterprises, thus effectively promoting the growth of total factor productivity.

To sum up, the digital transformation of enterprises can improve the total factor productivity by improving innovation performance. In short, digital transformation indirectly promotes the improvement of the total factor productivity of enterprises through the bridge of innovation performance.

6. The path of digital transformation affecting TFP

Through reading the literature, it can be seen that the impact of digital transformation on the total factor productivity of enterprises is diverse, mainly including: Reduce management costs and improve management efficiency; optimize the allocation of resources, enhance economies of scale; design organizational structure, speed up the decision-making response; expand customer relationships and improve customer satisfaction. These paths work together on enterprises and promote their total factor productivity. This paper selects the first two to do a detailed review, specifically on its mode of action.

6.1. Digital transformation promotes TFP by reducing costs and improving efficiency.

Digital transformation can reduce management costs, improve management efficiency, and promote the growth of total factor productivity of enterprises. The existing literature points out that digital transformation can optimize the internal management process of enterprises, thereby reducing operating costs and, at the same time, enhancing the efficiency of internal and external information transmission enterprises, bringing many benefits to enterprises.

First of all, digital transformation can reduce the operating costs of enterprises in an all-round way, achieve a significant increase in profits and benefits, and thus promote the growth of total factor productivity. First, the development of digital information technology has effectively alleviated the problem of information asymmetry, reduced the cost of information search, and improved the efficiency of resource utilization. Zhao proposed that digital transformation can effectively improve the information utilization rate of enterprises, and then enhance total factor productivity through cost control[7]. Second, the deep integration of digital technology and Internet business model has spawned a new model of sharing economy. Cheng mentioned that in the manufacturing industry and many small and medium-sized enterprises, expensive equipment and instruments not only occupy enterprise resources, but also increase management costs, and digital transformation is becoming an effective way to solve this problem[17]. Furthermore, digital transformation can also improve management efficiency by optimizing the production process, supply chain management and customer relationship management of enterprises. First, digital transformation will expand the scope of data applications and optimize data quality. Second, digital transformation will enhance the

synergy within the enterprise. Du found that digital transformation promotes enterprise performance by improving internal management efficiency and optimizes internal communication and collaboration paths[18].

In summary, digital transformation promotes the improvement of total factor productivity of enterprises by reducing operating costs, solving information asymmetry problems, spawning a new model of sharing economy, optimizing production processes, improving supply chain management and customer relationship management, enhancing internal synergy, and optimizing from the perspective of value creation.

6.2. Digital transformation promotes TFP by enhancing economies of scale.

Digital transformation can promote enterprise total factor productivity by enhancing economies of scale. Scale economy means that when the production scale expands, the unit product cost decreases, and the production efficiency increases. In the digital transformation process, enterprises can use information technology and digital means to achieve large-scale, efficient, and accurate production and management, thus improving the total factor productivity of enterprises.

First of all, through the wide application of digital technology, enterprises can achieve the best allocation of resources. First, the wide application of digital technologies such as artificial intelligence and robotics is prompting digital intelligence to gradually penetrate into the interaction within the organization. Wu emphasized that intelligent interconnected machinery and equipment can automatically execute instructions and realize the automation and standardization of production processes, so as to effectively coordinate and complement capital and advanced labor factors. Second, industrial digitization has effectively promoted the realization of enterprise economies of scale by integrating digital and traditional production factors. Liu concluded that in this process, technological innovation and the empowerment of data factors have played a key role in jointly promoting the improvement of total factor productivity of enterprises. Furthermore, digital transformation can achieve economies of scale by expanding markets and optimizing resource allocation. First, digital technology can optimize the allocation of factors such as capital and labor, and effectively solve the problem of " resource mismatch. " Huang pointed out that enterprises can not only increase their sales and market share by using Internet technology and e-commerce platforms, but also optimize resource allocation and improve production efficiency[19]. Second, digital transformation contributes to the synergy and integration between enterprises, and promotes scale growth and efficiency improvement. Han mentioned that the use of digital technology to accelerate the flow of enterprise factors can achieve resource sharing and complementary advantages, thereby improving the efficiency of enterprise capacity utilization and allocation efficiency[20].

Scholars have carried out many discussions on the path of digital transformation of enterprises. In general, enterprises should formulate targeted transformation strategies based on their needs, resources and other conditions to achieve the transformation goals. However, the existing research focuses on the whole industry level, and the systematic research on specific types of enterprises is still insufficient. At the same time, the digital transformation of enterprises is a process of continuous change, but the existing research mainly focuses on the transformation performance, ignoring its dynamics, resulting in research bias. Future research should further collect empirical data and comprehensively verify existing theories better to guide the practice of digital transformation of enterprises.

7. Conclusion and Discussion

7.1. Conclusion

In the wave of digital transformation, research on the total factor productivity of enterprises has become an important field of concern. This paper summarizes the following conclusions by sorting out and summarizing the relevant literature.

First of all, digital transformation significantly impacts the total factor productivity of enterprises. This effect is not only reflected in the improvement of production efficiency but also in the improvement of market share, the reduction of management cost, the enhancement of innovation ability and so on. Therefore, enterprises can optimize and upgrade the operation mode through digital transformation, and achieve more efficient management and operation in all aspects, so as to improve total factor productivity.

Secondly, the mechanism of digital transformation on the total factor productivity of enterprises is a complex process. In this process, various factors such as human capital structure, innovation performance, green innovation, corporate governance model, labor skill structure and so on have played an intermediary role. These factors affect the total factor productivity of enterprises by reducing management costs, improving management efficiency, enhancing economies of scale, market expansion, resource allocation and so on. Therefore, enterprises can optimize the structure of human capital and the ratio of investment to output, and screen innovative projects, so as to further improve total factor productivity.

7.2. Discussion

Although the existing literature has extensively discussed the relationship between digital transformation and total factor productivity, there are still some deficiencies and limitations in the research.

First of all, most studies focus on the macro impact of digital transformation, while the micro effects at the enterprise level are insufficiently discussed. Secondly, the existing literature often lacks a unified theoretical framework and quantitative indicators when measuring the relationship between digital transformation and total factor productivity, which makes it difficult to compare the research results horizontally. Thirdly, the multidimensional characteristics of digital transformation, such as technology adoption, organizational change and cultural adaptation, have not been fully considered, which limits the possibility of in-depth understanding of the impact mechanism of total factor productivity. Fourthly, many studies have not fully considered industry characteristics and enterprise heterogeneity, ignoring the specific challenges and opportunities that different industries and enterprises may face in the process of digital transformation. Fifth, the existing research is often limited in time span and geographical scope, and lacks comprehensive analysis across periods and countries, which limits the universal applicability and policy guiding significance of the research conclusions. Finally, although some literature attempts to introduce moderating variables to explore the complex relationship between digital transformation and total factor productivity, the selection and application of these moderating variables still need to be further systematized and theorized.

Therefore, future research needs to strengthen the construction of theoretical framework, the unification of quantitative indicators, the consideration of industry and

enterprise heterogeneity, and the comprehensive analysis across time and space, improve data quality and sample clarity, and extend the research cycle, so as to more accurately measure the impact of digital transformation. In addition, interdisciplinary cooperation will form a more comprehensive perspective to help reveal the specific implementation process and effects of digital transformation. Finally, the research results will provide guidance for policy formulation and enterprise practice, help enterprises effectively cope with the risks and challenges in digital transformation, and achieve sustainable development.

In short, the impact of digital transformation on the total factor productivity of enterprises is a complex and important field, which needs further in-depth study and discussion. It is hoped that more research and practice will be carried out in this field in the future to make greater contributions to the development of enterprises and the progress of society.

This study also has some limitations. First of all, this paper mainly focuses on the academic literature from 2004 to 2024, failing to cover earlier or latest research results, which may lead to an incomplete understanding of the impact mechanism of digital transformation. Secondly, the research is mainly based on the literature of the domestic core database CNKI, which may have regional deviations and fail to fully consider the international research perspectives and results. At the same time, the lack of in-depth analysis of the characteristics of different industries may affect the accurate assessment of the impact of digital transformation in specific industries. Finally, digital transformation is a process of continuous development. This paper may not fully consider its dynamic and long-term effects in the analysis. Future research can focus on the long-term effects and evolution trends of digital transformation.

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