

A Review of Research on Digital Transformation in Construction Enterprises

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Abstract: In the context of the national "14th Five-Year Plan", digital transformation is a necessary path for the high-quality development of the construction industry. Taking the 210 related literature searched and selected from China Knowledge Network as the primary data, Citespace was used to visualize and analyze the research hotspots, clustering changes, and evolutionary trends of digital transformation of construction enterprises. Combining the knowledge graph analysis and article review, the co-occurrence frequency and mediated centrality of hot keywords are derived, and the clustering analysis of the mediated centrality of keywords yields nine clustering units with the most excellent attention, which identifies the focuses and deficiencies of the research on the digital transformation of construction enterprises, and puts forward the outlook in terms of the paths and methods, benefits and costs, risks, case studies, as well as data, evaluation, and feedback.

Keywords: Construction companies; Digital transformation; Visual analytics; Citespace.

1. Introduction

The construction industry is one of the oldest traditional industries of humanity. After thousands of years of development, the construction industry is still a pillar industry that has a bearing on the national economy, people's livelihood, and historical inheritance. However, the construction industry is lagging, the traditional model is unsustainable, and the whole industry is in urgent need of transformation and upgrading.

With the rapid development of big data and Internet technology, the "14th Five-Year Plan" clearly put forward to promote the digital transformation of industry, China has officially entered a new stage of digital transformation. The booming development of the digital economy forces enterprises to face the pressure of transformation; the construction industry is an integral part of the national economy, but many construction enterprises are still at a low level of digitization, with a lack of awareness of their digital transformation capabilities. Nowadays, China's economic growth has entered a relatively severe period of attack, the construction industry to change the mode of development, and the realization of lean management is imminent. Digital transformation has just become the construction industry to comply with the requirements of the times to achieve high-quality development of the road to be taken. In this context, academic research on the digital transformation of construction enterprises has become more and more in-depth. In the current educational research, the essence of the digital transformation of construction enterprises is systematic remodeling to improve control and expansion, enhance development resilience, and achieve high-quality development. Past research has mainly focused on the decision-making factors, influencing factors, and implementation strategies of digital transformation of construction enterprises. Still, it has not formed a complete theoretical framework and methodological system.

This paper adopts bibliometric analysis and scientific knowledge mapping visualization and analysis methods to comprehensively analyze and summarize the development of

digital transformation of construction enterprises over the years 2004-2024. Research hot trends, critical research content progress, research deficiencies, and outlook are discussed to provide a reference for future research on the digital transformation of construction enterprises.

2. Research Tools, Data Sources, And Research Methodology

2.1. Data sources

The scope of the papers reviewed and analyzed in this research paper is the papers related to the digital transformation of construction enterprises published in Chinese journals, Chinese core journals, or CSSCI or CSCD journals included in SCI or EI in the ZhiNET database since 2004. During the search process, the option of Chinese-English extension was checked. Combining the ZhiNET systematic search and manual screening, this paper finally identifies the domestic construction enterprise digital transformation research literature database consisting of 210 articles. It carries out the knowledge graph visualization analysis and review analysis combined.

2.2. Analysis Methods

The research on the digital transformation of construction enterprises is a complex issue involving multiple disciplinary fields, which requires a multifaceted literature review to obtain the corresponding data sources. At present, a large number of research results have been published in a variety of academic journals, conference papers, and professional writings, and there are complex citation relationships and knowledge transfer networks between these documents. In this context, citing space software can be used to visualize and analyze the relevant literature to quickly access and understand the data sources and academic hotspots in the research on the digital transformation of construction enterprises. To establish a knowledge map of the research field of digital transformation of construction enterprises and identify the critical research themes and academic hotspots in it, and to understand the core ideas and leading research

directions in the research of digital transformation of construction enterprises. Keyword co-occurrence analysis of construction enterprise digital transformation research is performed by CiteSpace software to obtain relevant data sources. By developing a keyword list, keywords can be extracted, and co-occurrence analysis can be performed on the literature in the field of digital transformation research in construction enterprises to discover the critical hot issues and knowledge systems in the related fields.

3. Analysis of Keyword Hot Spots and Research Topics for Digital Transformation of Construction Enterprises

3.1. Keyword hotspot analysis

Keywords are the condensation of the critical points of the article's research content and methodology, and the research direction and essential issues of the field can be understood through the hotspot analysis of keywords. Their co-occurrence frequency mainly reflects the research hotspots in this field, while the mediational centrality of keywords specifically elucidates the intrinsic connection between keywords. Through the analysis of the co-occurrence frequency and mediocentricity scale of the 210 articles mentioned above (Table 1), it is found that the top 8 hot keywords related to the digital transformation of construction

enterprises are, in order, "digitization, intelligent construction site, digital economy, digital construction, construction platform, informatization, cloud computing, and the whole industry chain," which highlight the hot direction of the digital transformation research of construction enterprises. This highlights the desirable direction of digital transformation research in construction enterprises. The top-ranking groups of keywords, such as construction enterprises, construction industry, and construction industry, also highlight the key research targets of the digital transformation of construction enterprises. Through the keyword co-occurrence knowledge graph, it can be seen that "construction enterprise, construction industry, construction industry, digitization, and smart site," as the central node in the hot network knowledge graph, undertakes the starting point of the research in the field of digital transformation of construction enterprises, "construction industry, digital economy, digital construction, and construction platform," "construction industry, digital economy, digital construction and construction platform," and "construction industry, digital economy, digital construction, and construction platform," as well as the central nodes in the hot network knowledge graph. Economy, digital construction, and construction platform" as the secondary nodes, connecting the main keywords with specific keywords and assuming the role of particular implementation landing points in the research of digital transformation of construction enterprises.

Table 1. Information statistics of hot words in digital transformation research of construction enterprises

Frequency	Centrality	Keywords
42	0.48	Construction Companies
33	0.49	Construction Industry
22	0.25	Construction Industry
18	0.28	Digitalization
10	0.32	Smart Site
9	0.03	Construction Industry
9	0.07	Guanglinda
6	0.03	Digital Economy
6	0.06	Digital Construction
4	0.01	Construction Platform
4	0.02	Industry-Finance Integration
3	0.01	Informatization
3	0.05	Cloud Computing
3	0.04	Construction Enterprise
3	0.03	Industry Chain
3	0	Supply Chain
3	0.04	Enterprise Transformation

3.2. Keyword Thematic Analysis

3.2.1. Keyword Clustering Characterization

Research clustering is based on hotspot network mapping by refining and summarizing the research themes to visualize the main research areas. Through the cluster analysis of keyword intermediary centrality, the analysis results in nine clustering units with the highest degree of attention, which are "#0 construction enterprise, #1 intelligent construction site, #2 industry, and finance integration, #3 digitalization, #4 construction industry, #5 construction industry, #6 management structure, #7 Beijing urban sub-center, and #8 risk management and control.

Most of the keywords have a high degree of overlapping clusters, with varying degrees of linkage between the clustering units, indicating that co-citation is common

between such clustering units.

3.2.2. Research topic type division

According to the keyword timeline knowledge map, combined with the focused literature reading analysis of each cluster, the digital transformation factors of construction enterprises can be divided.

For clustering unit #0 construction enterprises, the existing literature on the digital transformation of construction enterprises mainly focuses on the study of large construction central enterprises. The research on large construction major enterprises primarily focuses on the analysis of its specific realization methods in promoting the construction of the digital economy, Yang Xiangge and Jiang culture to a large construction central enterprises as an example, under the guidance of the digital development platform theoretical

system and realization methods, to elaborate the specific practice of the large construction significant enterprises in the digital development [1]; Wan Li from the analysis of the construction industry to influence the "two gold Wan Li from the analysis of factors affecting the scale of the construction industry "two gold" to start, around the source control, process supervision, the end of the liquidation of the three links, put forward the "two gold" pressure to reduce the specific recommendations [2]; In addition to these three links, Zhang Kai and Wei Shaolei from the perspective of the development of the organization management model, analysis of enterprises, project operation and control focus on the evolution, identify in the digital era. Evolution, place the new situation in the digital era, the risks and opportunities facing the enterprise [3]; which in accordance with the digital control logic and application requirements, analysis of key risk trends, and then promote the overall formation of the enterprise data-driven decision-making work culture, so that the data analysis of the enterprise's core competitiveness, to control the risk of risk in the enterprise within the scope of the risk tolerance, for the sustainable development of the enterprise escort [4]; In addition to this, in the study of digital transformation of the construction central enterprises is mainly on the enterprise operation links and digital transformation development aspects of the study, most of the studies use the formulation of policies to promote the digital transformation of the enterprise, Li Chun, Zhang Yi and Li Qiu from the perspective of the destructive innovation theory, puts forward the main ideas of digital transformation of the architectural design class of enterprises [5]; Xu Man puts forward the demand for the structure of the digital talent with the Talent resource planning points and digital talent team construction strategy to contribute to the digital transformation of construction enterprises [6]; it can be seen that the digital transformation of construction enterprises can not be separated from the needs of the talent team.

Zhang Zhang, Zhou Xinwang and Long Chengzhu introduce BIM technology as a new technology, so that it optimizes the production process of the whole life cycle of construction projects and obtains the corresponding social effects, but also makes the construction enterprises in the digital transformation will face the pains of personnel structural adjustment, enterprise management mode adjustment and so on [7]; not only that, Jia Li and Wang Longmei establish the financial digital transformation of BIM technology and the architectural enterprise fusion framework, and CM company as an example, examples to prove the specific path of economic digital transformation based on BIM technology [8]; In addition, for the development of digital transformation of architectural design enterprises, Tang Chongwu from the perspective of BIM technology fusion of design results, project management, and enterprise management to elaborate the development of digital transformation of architectural design enterprises [9]; BIM technology has become a kind of digital transformation that has been commonly used in the construction industry. BIM technology has become a digital technology that is widely used in the construction industry and has become an essential driving force for the digital transformation of construction enterprises. Zhang Ning takes BIM technology as the driving force and foothold of the digital transformation of construction enterprises and adopts the fuzzy set qualitative comparative analysis method to explore the group effect of the influencing factors of the digital transformation of

construction enterprises driven by BIM [10]; it can be seen that BIM technology is also an essential force for promoting the digital transformation and intelligent development of the construction industry. Transformation and intellectual development of the construction industry.

There is more and more research on the clustering unit #1 brilliant site, which is the industry embodiment of the intelligent earth concept in the engineering field and is a brand new concept of the whole life cycle management of engineering. Jiang Jianhua, Zeng Yi, Chen Zhihui, and Weng Zhixiong pointed out that the digital twin of BIM is the core structure of the intelligent site and intelligent city, urging or leading the traditional construction industry multi-disciplinary digital transformation of the whole process [11]; In addition, Fang Weihua and Og Zonggang pointed out that the smart city is not the fusion of the traditional institutional framework and modern information technology, and is not purely a product of the current information technology. In the future, the development dilemma of the smart city should be cracked through "data centralized coordination, negative list incentive, networked governance, to build a 'human' city" and other ways to promote the development of digital transformation of construction enterprises [12]; not only that, Wen Wusong, Mao Weiqi and Tao Shifeng take the information tracing foundation of industrial Internet as the framework, use information model as the carrier to realize data sharing and business integration, realize the digital intelligent upgrade of the bridge construction process, and build the digital twin-driven bridge intelligent construction. At the same time, the innovative construction site is built to improve production efficiency, realize intelligent operation and maintenance monitoring during the operation period of the bridge, and construct an integrated comprehensive management platform for bridge intelligent construction and intelligent service to create an advanced model for the digital transformation and intelligent upgrading of China's transportation infrastructure [13]; therefore, the innovative construction site has a positive impact on the digital transformation of construction enterprises, provides enterprises with more efficient and accurate data analysis and decision-making support, which helps enterprises better deploy resources, optimize operations, and improve competitiveness. At the same time, it also needs the support and promotion of construction enterprises and related departments and organizations to jointly promote the digital transformation and sustainable development of the construction industry.

Through the analysis of the clustering unit #2 industry-finance integration, it is found that the importance of digital technology in enterprise operation and management, and digital transformation can effectively help enterprises achieve more efficient production and better quality management, which is an essential driving force for the operation and development of IPO enterprises [14]; in the field of accounting digitization, the integration of industry-finance can strengthen the endowment of information resources as well as the efficiency of information transmission, which is an essential basis for accounting digitization to In addition, for coal enterprises, Sun Jian put forward the strategic concept and realization path of enterprise financial management transformation when analyzing the industry-finance integration and digital transformation of coal enterprises [16]; for the medical industry, Liu Zhenping and Zhang Yu pointed out that through the analysis of the financial digital

transformation of public hospitals, it is necessary to build an industry-finance integrated digital economic system to achieve the goal of "financial integration and digital transformation of public hospitals". The various systems are interconnected; data sharing improves the level of exemplary management of public hospitals and helps public hospitals to develop with high quality [17]. In summary, it can be seen that there are relatively few studies on the digital transformation of construction enterprises under the integration of industry and finance. Although at this stage, some construction enterprises have applied the industry-finance integration model, in practice, the degree of industry-finance integration and the degree of fit is insufficient, and the industry-finance integration communication channels need to be improved.

3.2.3. Trends of Research Hot Spots

Through the characterization of the annual literature issuance volume, it is possible to understand the development of research concerns at various time stages, examine the laws and driving forces behind the changes in research hotspots, and provide directions for future research. From the point of view of the characteristics of changes in the volume of digital transformation of construction enterprises in time (Figure 1), it reflects the characteristics of the distribution of research

hotness at different stages, which in turn leads to the development trend of related research [18]. In China, the concept of digital transformation first appeared in Made 2025 in 2015. Its significance lies in shifting the focus of manufacturing development from scale expansion to quality improvement and improving technological innovation capability. Initially, digital transformation focused on the manufacturing industry and gradually moved from manufacturing to the construction industry in 2017. At that time, the Chinese government wanted to implement the digital China strategy fully, with the purpose and leadership of building a digital China to promote economic development, improve social governance and public services, and enhance the modernization of national governance. As a result, research on the digital transformation of construction enterprises began to emerge after that year. By 2021, the research on the digital transformation of construction enterprises reached a peak compared to the previous years, marking China's official and substantial steps in the field of digital transformation of construction enterprises. Pilots will first be implemented in Guangdong and Shenzhen to encourage the digital transformation of construction firms and to lay the foundation for a comprehensive industrial transformation in China in the future.

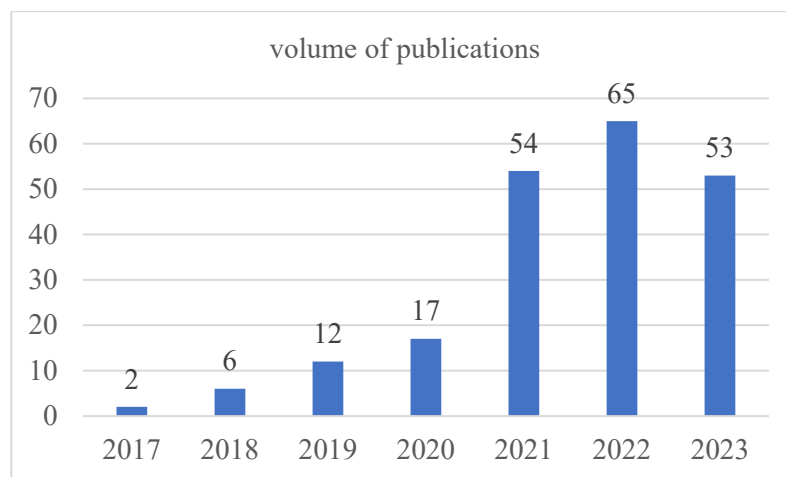


Figure 1. Annual trend of digital transformation postings by construction companies

4. Summary and Analysis of The Research Content of Digital Transformation of Construction Enterprises

Digital transformation of construction enterprises is a significant trend in the future development of the construction industry, aiming to improve efficiency, reduce costs, optimize resource utilization, and reduce environmental impact. It is a complex and critical process that involves multiple aspects, including strategic planning, organizational change, technological innovation, talent training, data security, and so on.

Strategic planning for digital transformation [19]. Research has shown that due to the high complexity of the production system of construction enterprises and the many specialized fields involved, to ensure the effective promotion of digital transformation within the enterprise, construction enterprises need to establish a set of digital transformation guarantee mechanisms. Based on the overall strategic adjustment to form a digital top-level planning, clear goals and vision, the

whole bureau up and down the chessboard, systematic planning, and step-by-step implementation to ensure that the digital transformation strategy falls into place.

Organizational change for digital transformation [20]. As a significant change, digital transformation is bound to face resistance from all sides. Therefore, it is necessary to strengthen organizational leadership, improve the corporate system, and clarify the main body of promotion to ensure the effective promotion of digital transformation. In the process of digital transformation, a leading group for digital transformation with a hand-in-charge system is established, which is fully responsible for the digital transformation work of the enterprise, including researching and formulating the digital transformation roadmap, making decisions on critical tasks, and coordinating and solving significant problems in the transformation process. At the same time, the division of responsibilities of various departments and subjects is clarified, and the digital transformation is promoted in a concerted manner to form an effective synergy. This can provide a strong guarantee for the digital transformation of enterprises.

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