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# The Impact of Enterprise Digital Transformation on Service Innovation Performance -- Taking the construction enterprises in the Yangtze River Delta as the research object

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## Abstract

Guided by the rapid development of digital economy and service economy, digital transformation has become a key strategy to enhance the service innovation performance of Chinese enterprises. Therefore, this research will base the digital transformation of construction enterprises on BIM technology, use BIM based digital transformation as the engine to promote the realization of service innovation of construction enterprises, and explore the impact relationship between BIM based digital transformation and service innovation performance. Based on the introduction of the above variables, this study has built a theoretical model of BIM-based digital transformation, business model and service innovation performance under the regulation of environmental dynamics. To test the theoretical model, this study takes the construction enterprises in the Yangtze River Delta region as the research object, takes the online and offline questionnaire surveys as the data collection method, takes the structural equation model and the potential regulatory structural equation model as the relationship test method, and uses three statistical software tools, SPSS21.0, AMOS17.0, and MPLUS7.4, to complete the model test. The research results show that, first, BIM-based digital transformation has a significant positive impact on service innovation performance; Second, the business model plays a 43.19% part in the mediating effect between BIM-based digital transformation and service innovation performance; Third, the impact of environmental dynamics on BIM-based digital transformation, service innovation performance and business model is significant in the second half of the relationship, but not in the first half.

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**Keywords:** *BIM, business model, digitalization, environmental dynamics, service innovation performance.*

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## Introduction

According to the report of the World Economic Organization, the construction industry currently accounts for 6% of the world GDP and is expected to account for 14.7% in 2030. And with the updating and iteration of science and technology, new technologies such as big data, cloud computing, BIM, VR and AI are deeply integrated with the construction industry, accelerating the transformation of China's construction industry to digitalization and service. However, under the stimulation of the complex and dynamic external environment, China's construction industry is still an extensive labor-intensive industry. There are problems such as backward production mode, low degree of modernization, and insufficient innovation motivation, which seriously hinder the transformation and development of the construction industry (Yang & Chen 2021; Fang 2021; Xia, 2010). And digitalization is a new element and engine of digital economy driven development, which can promote the birth of new products, new business types, new models and new management, and rebuild new momentum of development. In the construction industry, digital transformation is to realize the upgrading of the whole business process of the construction industry enterprises and the reconstruction and innovation of the enterprise business model. The business model is an effective way to realize the value of service innovation, and service innovation performance is an important basis for the transformation of the construction industry's digital economy (Zhang & Shen 2022; Jiang & Shi, 2010). Therefore, how to promote the improvement of service innovation performance and the continuous optimization of business model of construction enterprises through digital transformation, and realize the transformation of digital economy and service-oriented transformation of the construction industry, is an important problem that needs to be solved at the current stage of transformation and development of China's construction industry. (Zhang & Shen2022; Yang & Chen 2021)

### Problem Statement

The informatization of the construction industry is an important part of the development strategy of the construction industry, and also an inevitable requirement for the transformation of the development mode, quality and efficiency improvement, energy conservation and emission reduction of the construction industry. It is of great significance for the green development of the construction industry and the improvement of people's quality of life (Zhang & Shen2022). The informatization of the construction industry is an important part of the development strategy of the construction industry, and also an inevitable requirement for the transformation of the development mode, quality and efficiency improvement, energy conservation and emission reduction of the construction industry. It is of great significance for the green development of the construction industry and the improvement of the quality of people's lives (Zhang & Shen 2022). This study studies the impact of BIM driven digital transformation of construction enterprises in the Yangtze River Delta on service innovation performance. Because the rapid development of Internet technology is emerging in recent years, which also leads to the research on BIM driven digital transformation is also subject to certain restrictions. Taking the construction enterprises in the Yangtze River Delta as an example, this study is to fill the academic gap on BIM digital transformation on the one hand, and on the other hand, it can also start from BIM driven digital transformation, Some suggestions are put forward to improve the service innovation performance of construction enterprises in the Yangtze River Delta. According to the practical challenges and knowledge gaps in the previous section of the question review, this study proposes the following four research questions.

1、What is the service innovation performance level of construction enterprises in the Yangtze River Delta?

2、How does BIM based digital transformation affect service innovation performance of construction enterprises in the Yangtze River Delta?
3、Is there a mediating effect of business model in the relationship between BIM based digital transformation and service innovation performance of construction enterprises in the Yangtze River Delta?
4、Does environmental dynamics have a moderating effect in the relationship between BIM based digital transformation and business model and service innovation performance?

## Literature review

### BIM-based Digital Transformation

BIM is the abbreviation of Building Information Modeling, and is considered as an indispensable tool for building smart cities. BIM has the characteristics of intelligent, visual and dynamic design management, which can greatly improve the efficiency of engineering construction and reduce engineering construction errors. It is very important for the design and construction of engineering buildings, especially large buildings. If the digital transformation in the manufacturing industry is defined as Industry 4.0, then the digital transformation in the construction industry is defined as Architecture 4.0 (Tian et al., 2021). Building 4.0 is the fourth industrial revolution in the construction industry. It connects virtual buildings and physical buildings through the BIM system to achieve digitalization from information production to a higher level. The Transportation Authority of New South Wales of the United States combines emerging technologies with structured data to propose the concept of digital engineering; The British Building Digital Center proposed the vision of combining BIM technology with other advanced technologies such as the Internet of Things in the next decade, digitizing the whole life cycle of buildings, and improving public service capabilities through innovative ways. The construction industry is an important part of the real economy, and the entry of emerging technologies has forced the transformation of the construction industry to become inevitable (Wang, 2014). However, compared with other traditional industries, the adoption of new technologies in the construction industry is relatively slow. In the past 50 years, although new technologies such as big data, cloud computing, BIM, VR and AI have been emerging, the adoption of new technologies and processes in the construction industry is very slow. The business model has not undergone fundamental changes, and the production efficiency has basically not improved (Gong & Duan, 2022). However, with several global trends - urban migration, climate change and new global push for infrastructure, the industry will become more important. With the development of information technology, 40% of the world's customers and consumers are digital users, and those enterprises that cannot keep up with the pace of the times will face the risk of being forced out of the market (You et al., 2021). The application of digital transformation in the construction industry is mainly to realize the upgrading of the whole business process, the reconstruction and innovation of the business model, and the improvement of the enterprise management level (Lu, 2021). The digital transformation of construction enterprises is not a simple application of information technology, but a process that requires the deep integration of new technology and construction enterprise business, management and business model (Du, 2021). The development of Internet, big data, cloud computing and other emerging technologies has changed the business model of traditional construction enterprises from enterprises to customers, focusing on customers and providing personalized and customized services for customers. It has changed the original model of what customers buy and what customers produce into a new model of what enterprises produce and what customers need. The above-mentioned new model pays more attention to the improvement of customer satisfaction, breaks the dilemma of low satisfaction of existing industry customers with the service products provided by the construction industry, softens the barriers for construction enterprises to adopt new technologies and achieve digital transformation, realizes the digital transformation of construction enterprises as soon as possible, and improves the production efficiency of construction enterprises (Wang & Chen, 2021). Recently, there is relatively little research on the digital transformation of construction enterprises outside China. The World Economic Organization put forward a framework for the transformation of construction enterprises in its article Shaping the Future of the Construction Industry -- Thinking and Technological Breakthrough. It listed 6 transformation ways and 30 transformation measures from the company level, department level and government level (Zhang, 2020). The framework has been applied in many practical projects, and has achieved good results in achieving leapfrog development of industry productivity and innovation. However, there is no relevant shaping framework for the digital transformation of construction enterprises. Koscheyev (2019) and others comprehensively analyzed the principles and objectives, implementation tools and maturity evaluation of the digital transformation of the construction industry, and pointed out that the digital transformation of construction enterprises should be based on five aspects. First, integrate digitalization into the existing enterprise operation system, and build transparent information of construction stakeholders as much as possible; Second, standardize and rationalize technology and business processes; Third, adjust the organizational structure to adapt to the digital transformation; Fourth, form a corporate digital transformation culture, and support digital transformation by all staff; Fifth, based on financial and economic activities, revise the five principles of digital transformation investment efficiency evaluation indicators. The digital capability matrix of the construction industry developed by Roland Berger, an international consulting company, has identified seven goals for the digital transformation of the construction industry, which are in turn digital tools, digital platforms for material procurement, optimization of business and construction organization processes, smart tools, digital marketing, digital tools for services, and BIM technology platforms. These goals are also the vision of existing construction enterprises to carry out digital transformation and encourage enterprises to promote the process of digital transformation (Wang et al., 2019). The digital transformation of the construction industry must provide the required or higher quality construction products at a lower price in a short time, and fully improve the safety performance and energy efficiency of the construction products. However, existing research shows that BIM drive is a booster of digital transformation of construction enterprises, and can play a core role in accelerating the digital transformation of construction enterprises (Zheng & Jiang, 2022). Flavio (2011) and others put forward the concept of building 4.0 by taking digital architecture as the research object and analogy with Industry 4.0, which uses digital technology to improve quality and productivity in other industrial fields. They believed that digital architecture can improve enterprise productivity, reduce schedule delays and cost overruns, and improve safety, quality and resource utilization efficiency. BIM is the key technology to achieve this process and goal. The British Building Digital Center believes that the application of digital technology has changed the whole life cycle of design, construction, operation and maintenance of social and economic infrastructure construction, and BIM technology has achieved the transformation of the British building industry (Guo, 2021). BIM drive can break the barriers of the traditional construction industry chain, realize the cooperation and sharing between upstream and downstream enterprises of the industry chain, transform the highly integrated management thinking mode of information throughout the life cycle of the construction industry into the BIM driven digital transformation of the construction industry enterprises, and achieve the goal of digital economy driven development and industrial transformation and upgrading of the construction industry (Liu & Zhang, 2021; Jiang & Wang, 2021). To sum up, this study believes that BIM driven digital transformation of construction enterprises is not only a simple application of BIM as a technology, but also an all-round transformation and innovation of enterprise business brought about by BIM, which is a comprehensive improvement of enterprise personnel, technology, management, environment, etc. Its core essence is the strategic business transformation driven by customer demand. With customers as the center of business transformation, it is a process of realizing business model innovation, product and service innovation, and providing customers with new service value.

**Service Innovation Performance**

Service innovation activities can bring benefits to enterprises and improve their business performance. However, due to the perishability, intangibility and simultaneous production and consumption of services, it is difficult to measure service innovation (Xu, 2014). Therefore, the measurement concept of service innovation performance came into being. The definition of service innovation performance is similar to that of service innovation. Different scholars have different perspectives and definitions (Wang & Yang, 2021). For example, Wang (2021) believes that service innovation performance is a concept of multiple reconstruction, which is a new service developed by an enterprise to meet the needs of its own, employees, customers, society and other stakeholders, or an evaluation of the efficiency and effect of existing service improvement activities; Avlonitisl (2001), based on the comparative study of service innovation, proposed that service innovation performance is a measure of the results of the process from the order in which service innovation occurs, according to what service innovation is, how it is generated, and who guides it; Jane et al. (2018), starting from the process and results of service innovation, believed that service innovation performance is an important indicator to measure the results of service innovation. This indicator is different from the common service performance, organizational performance and enterprise performance. It is a measure of the performance of enterprises through innovation to promote new service products or service processes. No matter what perspective scholars take or what kind of research object they face, the essence of their concept definition of service innovation performance is to measure the results of the activity of service innovation, which is a quantitative evaluation of the efficiency and effect of the activity. Service innovation performance is a measure of the efficiency and effect of service innovation. However, there is no unified standard for the division of service innovation performance evaluation and measurement dimensions. Through reading relevant domestic and foreign literature, this study found that different literature uses different measurement dimensions of service innovation performance due to different research objects and research contents. However, through summary, there are three schools of service innovation performance evaluation indicator system: The first is to measure service innovation performance from the process and result dimensions of Cooper and Kleinschmidt's (1994) integration and expansion. The process measurement includes cost, effectiveness and speed, while the result measurement includes finance, competitiveness and quality. The second is the financial performance, customer performance, internal performance and market performance indicator system developed by taking the project level financial indicators, customer indicators and internal indicators proposed by Storey and Kelly (2000), as well as the proportion of new products developed at the planning level, the average product development cost, and the number of new products as the core. The third is a service innovation performance indicator system with financial indicators and non-financial indicators proposed by Avlonitis (2001) as the main body. Financial performance is divided into profit, market share, profit expectation and other indicators; Non-financial performance is divided into enterprise perception image, customer loyalty, impact on other products of the enterprise, influx of new customers, new competitive advantages and other indicators.

### Business Model

Business model is an important way of value creation and value capture, while business model value creation and the measurement of the effect of acquisition are barometers of the competitiveness and vitality of an enterprise's value strategy (Wei et al., 2021). Therefore, this study adopts the business model to measure the enterprise value brought by the business model. Just as the definitions of business model are various, the measurement index system of business model is also different, but different from the multiple perspectives of business model definition, the measurement index of business model can be divided into two systems: The first is a system commonly used by domestic scholars to measure business model by the value generated by business model. Wang & Wang (2021) proposed that the core content of business model is customer value, internal value and cooperation value. Customer value meets customer value needs by improving products or services. Internal value is the operating mechanism and process for enterprises to realize value creation, and cooperation value is the value role of enterprises in the value chain. Ge (2021) proposed that business model is essentially a logical relationship of enterprise value creation, and value is created through the cooperation of customers, partners and enterprises. Therefore, he divided business model into three research components: customer value, partner value and enterprise value. Whether divided by customer value, internal value, value or customer value, partner value or enterprise value, the essence of the division is the same, but different scholars have different naming habits. Customers and customers are the same group. Internal value is the process of creating value through the internal operating mechanism of the enterprise, and cooperative value is the value created by partners through cooperation. Therefore, this study will integrate the two, combine the industry characteristics of the construction industry, and select customer value, cooperation value and enterprise value as the core content of the business model of the construction industry. The second is the system used by foreign scholars to measure business model by business model value creation process. The above system mainly focuses on 3-5 dimensions, and most researchers use value provision, value creation, value capture, three dimensions (Li, 2020). Value provision is the most important part of the business model value chain. It can achieve the goal of customer value proposition by providing products, services, solutions, experiences, information and content (Chen & Xu, 2020). Value creation refers to the arrangement of resources and activities during the operation of the business model. It develops and produces products or services that are valuable to customers through resources, capabilities, suppliers, partnerships, etc., giving full play to the role of the business model, and obtaining the maximum value output with the least optimal input. Value capture is a measure of the value realization effect of the business model. It specifically refers to the financial structure and profit model of the enterprise. It is an inherent part of the business model, reflecting how the enterprise provides funds for its operation and how to obtain profits (whether through cost reduction, supplier control, tax reduction, policy incentives or any other combination of measures).

### Environmental Dynamics

Environmental dynamics comes from the complexity and instability of the external environment of the enterprise. In a dynamic environment, various changes occur quickly and are not easy to detect, making it more difficult to measure environmental dynamics. At present, there are two types of environmental dynamics indicator systems. One is to focus on the generation of environment, and divide environmental dynamics into external environment and internal environment. Ge (2021) measured the dynamics of the external environment of the enterprise with four items, namely, "product or service update in the industry", "competitor behavior in the industry", "technological progress in the industry" and "customer demand change in the industry", while measured the dynamics of the internal environment with "marketing strategy change of the company", "flow of technical personnel of the company" and "change of senior management of the company". Zhang & Zhang (2020) focused on measuring environmental dynamics from the perspective of environment and key environmental factors, taking into account four issues: industry environment, competitor behavior, technological progress and customer demand. The other type focuses on the occurrence of dynamics, and divides environmental dynamics into demand dynamics, market dynamics, technology dynamics or policy environmental dynamics. Wei et al. (2021) took technology-based SMEs as the research object, took the two external environmental factors of market demand dynamics and technological development dynamics as dimensions, and considered environmental dynamics from two aspects of market dynamics and technological dynamics. Tan (2021) takes British family businesses as the research object, and measures environmental dynamics from three perspectives: market competition, technology development and customer demand change. Guo (2021) takes innovation and entrepreneurship enterprises as the research object, and measures the environmental dynamics of innovation and entrepreneurship enterprise transformation from three aspects: market environmental dynamics, policy environmental dynamics and technology environmental dynamics. In addition, through reading and sorting out foreign literature, it is found that the environmental dynamics measurement scale adopted by scholars is mainly based on four mature scales, which are Miller and Friesen (1978), Dess and Beard (1984), Jaworski and Kohli (1990), and Jansen (2007). Miller and Friesen (1978) put forward that dynamic is one of the three characteristics of business environment mainly from the perspective of business environment. Then Dess and Beard (1984) further extended to enterprise organization management, believing that dynamics and complexity are the essence of the uncertainty of the environment faced by enterprise organizations. Jaworski and Kohli (1990) deeply analyzed whether the impact of market orientation of enterprise organizations on employees and enterprise performance is related to the external environment, and proposed such environmental factors as market volatility, competition mechanism and technology volatility. Jansen (2007) combined the focus with innovation, studied the organizational antecedents and environmental moderating effect of exploratory innovation, and the changes in products and services promoted exploratory innovation, thereby improving the financial performance and enterprise performance of enterprises.

## Hypotheses

Based on the research objectives and literature review, the researcher proposed the research hypopaper of this study.

*H1*. BIM-based digital transformation is positively correlated with service innovation performance of construction enterprises in the Yangtze River Delta.

*H2*. Business model has a mediating effect between BIM-based digital transformation and service innovation performance of construction enterprises in the Yangtze River Delta.

*H2a*. BIM-based digital transformation is positively correlated with business model.

*H2b*. Business model is positively correlated with service innovation performance of construction enterprises in the Yangtze River Delta.

*H3*. Environmental dynamics has a moderating effect in the influence of BIM-based digital transformation on business model and business model on service innovation performance of construction enterprises in the Yangtze River Delta.

*H3a*. Environmental dynamics has a moderating effect in the relationship between BIM-based digital transformation and business model.

*H3b.* Environmental dynamics has a moderating effect in the relationship between business model and service innovation performance of construction enterprises in the Yangtze River Delta.

**Research Framework**

The research framework of this study is based on the whole life cycle digital transformation level and new product development performance model built by Schweitzer et al. (2019), and the transformational leadership and business model innovation and enterprise performance model regulated by environmental dynamics built by Li (2015), combining the cluster theory and the characteristics and requirements of the context theory model construction. Figure 2-3 is the theoretical model diagram of BIM based digital transformation, business model and service innovation performance under the regulation of environmental dynamics.

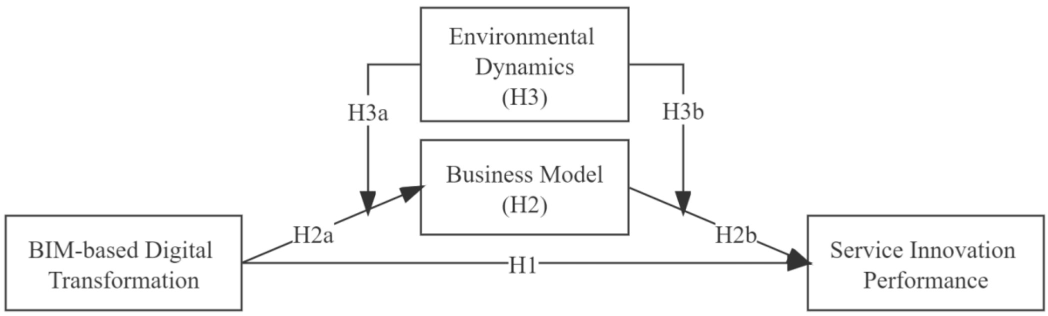


**Figure 2-1 Research Framework**
(Source: Author)

**Methodology**

**Research Design**

This paper adopts a quantitative research approach to explore the impact of BIM driven digital transformation of construction enterprises on service innovation performance. Through scientific data collection and data validation, research conclusions can be obtained; This paper analyzes the relationship between the independent variable BIM driven digital transformation of construction enterprises and the dependent variable service innovation performance. From the perspective of the research path of this study, the research goal was set at the beginning of the study. From general to special reasoning, a set of research hypotheses to be demonstrated was proposed. The realization and completion of the research objectives of this study are evaluated based on the establishment of research assumptions.

**3.2 Population/Sampling/Unit of Analysis**

In order to study the reform and development of construction enterprises in China and promote the scientific development of construction enterprises, this paper establishes an evaluation system, and selects the strong construction enterprises in the Yangtze River Delta as the research object. From the statistics of the Yangtze River Delta in 2019, there were 7129 general contracting and professional subcontracting enterprises above the qualification level in the Yangtze River Delta, an increase of 16.1% compared with last year. Krejcie and Morgan (1970) defined the sampling standard and provided a statistical overall sampling table. Therefore, this paper selects 16 construction enterprises in the Yangtze River Delta region as the research topic. Each construction enterprise issues 20 questionnaires, a total of 320 questionnaires. All questionnaires are distributed online. The online platform recovers 300 questionnaires, excluding 20 invalid ones, and 280 valid questionnaires. The effective recovery rate is 87.5%.

### *Profile of Respondents*

For the profile of responses, there are 280 valid formal questionnaires collected in this survey. The researcher summarized the information in the effective questionnaire and further sorted out the sample (respondents) information statistics table. See Table 1 for details.

**Table 1 Statistics of Basic Information of Samples (N=280)**

| Variables | Classification | Sample size | Proportion |
|---|---|---|---|
| Gender | Male | 160 | 57.14% |
| | Female | 120 | 42.86% |
| Age | 16-20 years old | 10 | 3.57% |
| | 21-30 years old | 120 | 42.86% |
| | 31-40 years old | 120 | 42.86% |
| | 41-50 years old | 20 | 7.14% |
| | 51-60 years old | 10 | 3.57% |
| Education level | Junior high school or below | 10 | 3.57% |
| | High school or technical secondary school | 20 | 7.14% |
| | Junior college | 50 | 17.86% |
| | Undergraduate | 150 | 53.57% |
| | Master or above | 50 | 17.86% |
| Position | Grass roots employees | 120 | 42.86% |
| | Grass roots managers | 60 | 21.43% |
| | Middle managers | 60 | 21.43% |
| | Senior Manager | 40 | 14.29% |
| Length of service | 0-5 years | 100 | 35.71% |
| | 6-10 years | 120 | 42.86% |
| | 11-20 years | 30 | 10.71% |
| | 21-30 years | 25 | 8.93% |
| | More than 30 years | 5 | 1.79% |

(Source: Author)

## Findings & Discussions

In this study, descriptive statistical analysis and Pearson correlation analysis were conducted for each principal variable. The results showed that the BIM-based digital transformation was positively correlated with the business model (=0.487, p<0.01); Digital transformation is positively correlated with service innovation performance (r=0.517, p<0.01); Business model was positively correlated with service innovation performance (r=0.543, p<0.01); The relationship between BIM-based digital transformation and environmental dynamics was not significant (r=0.113, p>0.05); There was a positive correlation between business model and environmental dynamics (=0.154. p<0.05); There was a positive correlation between service innovation performance and environmental dynamics (r=0.266, p<0.01). See Table 2 for detailed dimensional data.

**Table 2 Descriptive Statistical Analysis Results of Samples**

| | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| BIM-based Digital Transformation | 4.49 | 1.003 | 1 | | | | | | | |
| Business model | 4.56 | 1.085 | 0.487 | 1 | | | | | | |
| Service innovation performance | 4.49 | 1.003 | 0.517 | 0.543 | 1 | | | | | |
| Customer performance | 4.49 | 1.258 | 0.519 | 0.564 | 0.796 | 1 | | | | |
| Market performance | 4.38 | 1.215 | 0.415 | 0.448 | 0.813 | 0.556 | 1 | | | |
| Internal performance | 4.60 | 1.272 | 0.369 | 0.392 | 0.801 | 0.529 | 0.497 | 1 | | |
| Financial performance | 4.51 | 1.286 | 0.354 | 0.333 | 0.780 | 0.460 | 0.367 | 0.354 | 1 | |
| Environmental dynamics | 4.78 | 0.941 | 0.113 | 0.154* | 0.266 | 0.200 | 0.230 | 0.211 | 0.207 | 1 |

Note: * means p<0.05, other unspecified items are significant at p<0.01.
(Source: Author)

Whether the sample data conforms to the normal distribution is the premise of applying structural equation model to data analysis. Kline proposed that data conforming to the normal distribution should meet two conditions at the same time. The first condition is that the absolute value of kurtosis is less than 10; The second condition is that the absolute value of deflection is less than 3. Table 3 shows the normality analysis data of all items in the scale.

**Table 1 Test Results of Normal Distribution of Samples**

| Scale | Items | *N* | M | SD | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Statistic | SD | Statistic | SD |
| BIM-based digital transformation | DCU-1 | 280 | 5.02 | 1.575 | -0.812 | 0.146 | -0.515 | 0.291 |
| | DCU-2 | 280 | 4.91 | 4.363 | -0.124 | 0.146 | -0.645 | 0.291 |
| | DCU-3 | 280 | 4.94 | 1.358 | -0.145 | 0.146 | -0.365 | 0.291 |
| | DCU-4 | 280 | 4.89 | 1.363 | -0.754 | 0.146 | -0.451 | 0.291 |
| | RIN-1 | 280 | 4.77 | 1.418 | -0.478 | 0.146 | -0.369 | 0.291 |
| | RIN-2 | 280 | 4.79 | 1.492 | -0.147 | 0.146 | -0.458 | 0.291 |
| | RIN-3 | 280 | 4.81 | 1.607 | -0.654 | 0.146 | -0.698 | 0.291 |
| | POP-1 | 280 | 4.66 | 1.406 | -0.612 | 0.146 | -0.751 | 0.291 |
| | POP-2 | 280 | 4.72 | 1.254 | -0.512 | 0.146 | -0.598 | 0.291 |
| | POP-2 | 280 | 4.59 | 1.458 | -0.481 | 0.146 | -0.367 | 0.291 |
| | POP-4 | 280 | 4.69 | 1.451 | -0.178 | 0.146 | -0.789 | 0.291 |
| | TC-1 | 280 | 4.74 | 1.148 | -0.357 | 0.146 | -0.159 | 0.291 |
| | TC-2 | 280 | 4.77 | 1.487 | -0.615 | 0.146 | -0.784 | 0.291 |
| | TC-3 | 280 | 4.68 | 1.469 | -0.457 | 0.146 | -0.187 | 0.291 |
| | TC-4 | 280 | 4.69 | 1.480 | -0.781 | 0.146 | -0.771 | 0.291 |
| | CR-1 | 280 | 4.74 | 1.684 | -0.660 | 0.146 | -0.226 | 0.291 |
| | CR-2 | 280 | 4.77 | 1.458 | -0.612 | 0.146 | -0.336 | 0.291 |
| | CR-3 | 280 | 4.68 | 1.418 | -0.458 | 0.146 | -0.667 | 0.291 |
| Business model | VPR-1 | 280 | 4.65 | 1.541 | -0.457 | 0.146 | -0.446 | 0.291 |
| | VPR-2 | 280 | 4.61 | 1.648 | -0.123 | 0.146 | -0.997 | 0.291 |
| | VPR-3 | 280 | 4.57 | 1.485 | -0.179 | 0.146 | -0.449 | 0.291 |
| | VPR-4 | 280 | 4.55 | 1.647 | -0.456 | 0.146 | -0.215 | 0.291 |
| | VCR-1 | 280 | 4.45 | 1.874 | -0.657 | 0.146 | -0.368 | 0.291 |
| | VCR-2 | 280 | 4.53 | 1.468 | -0.486 | 0.146 | -0.125 | 0.291 |
| | VCR-3 | 280 | 4.45 | 1.506 | -0.558 | 0.146 | -0.657 | 0.291 |
| | WOC-1 | 280 | 4.60 | 1.523 | -0.527 | 0.146 | -0.489 | 0.291 |
| | WOC-2 | 280 | 4.55 | 1.254 | -0.694 | 0.146 | -0.579 | 0.291 |
| | WOC-3 | 280 | 4.65 | 1.576 | -0.364 | 0.146 | -0.786 | 0.291 |
| Service innovation performance | CP-1 | 280 | 4.52 | 1.571 | -0.456 | 0.146 | -0.743 | 0.291 |
| | CP-2 | 280 | 4.52 | 1.484 | -0.256 | 0.146 | -0.945 | 0.291 |
| | CP-3 | 280 | 4.42 | 1.486 | -0.658 | 0.146 | -0.268 | 0.291 |
| | MP-1 | 280 | 4.29 | 1.487 | -0.774 | 0.146 | -0.489 | 0.291 |
| | MP-2 | 280 | 4.40 | 1.485 | -0.719 | 0.146 | -0.479 | 0.291 |
| | MP-3 | 280 | 4.44 | 1.423 | -0.669 | 0.146 | -0.369 | 0.291 |
| | IP-1 | 280 | 4.54 | 1.412 | -0.666 | 0.146 | -0.158 | 0.291 |
| | IP-2 | 280 | 4.62 | 1.512 | -0.612 | 0.146 | -0.951 | 0.291 |
| | IP-3 | 280 | 4.47 | 1.531 | -0.128 | 0.146 | -0.247 | 0.291 |
| | FP-1 | 280 | 4.49 | 1.569 | -0.610 | 0.146 | -0.257 | 0.291 |
| | FP-2 | 280 | 4.56 | 1.550 | -0.741 | 0.146 | -0.510 | 0.291 |
| | FP-3 | 280 | 4.73 | 1.440 | -0.727 | 0.146 | -0.154 | 0.291 |
| Environmental dynamics | ED-1 | 280 | 4.86 | 1.410 | -0.726 | 0.146 | -0.587 | 0.291 |
| | ED-2 | 280 | 4.90 | 1.413 | -0.762 | 0.146 | -0.369 | 0.291 |
| | ED-3 | 280 | 4.90 | 1.154 | -0.123 | 0.146 | -0.267 | 0.291 |
| | ED-4 | 280 | 4.95 | 1.451 | -0.456 | 0.146 | -0.369 | 0.291 |
| | ED-5 | 280 | 4.83 | 1.495 | -0.478 | 0.146 | -0.187 | 0.291 |

(Source: Author)

According to Table 3 above, the absolute values of Skewness (Skewness) and Kurtosis (Kurtosis) of all items in this research scale are 0.210-0.812 and 0.013-0.757 respectively, which conform to normal distribution, so structural equation model analysis can be conducted.

The measurement method errors caused by measurement tools, data acquisition methods, subjective impression of survey objects and environment are called common method errors. In this study, a series of measures were taken to control common method bias and social desirability bias during the questionnaire design and operation stages. For example, each dimension of questionnaire design is designed with multiple items, and each construct is designed with multiple measurement dimensions; The questionnaire adopts the anonymous survey method of "online+offline"; Control of answering time, etc. In addition, in addition to control in the data collection process, Harman's single-factor test was used to conduct principal component analysis on the non rotated factors of each dimension, that is, 45 items were used together for exploratory factor analysis. The results are shown in Table 4:

**Table 2 Results of the Common Method Bias Test**

| Component | Extraction Sums of Squared Loadings | | | Component | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | | Total | % of Variance | Cumulative % |
| 1 | 13.197 | 29.326 | 29.326 | 7 | 1.387 | 3.082 | 61.145 |
| 2 | 3.718 | 8.263 | 37.588 | 8 | 1.358 | 3.017 | 64.162 |
| 3 | 3.321 | 7.380 | 44.968 | 9 | 1.210 | 2.689 | 66.851 |
| 4 | 2.540 | 5.644 | 50.612 | 10 | 1.154 | 2.565 | 69.416 |
| 5 | 1.748 | 3.873 | 54.612 | 11 | 1.142 | 2.538 | 71.954 |
| 6 | 1.617 | 3.578 | 58.063 | 12 | 1.009 | 2.242 | 74.196 |

(Source: Author)

According to Table 4 above, a total of 12 factors with eigenvalues greater than 1 have been extracted. The maximum explanatory capacity of a single factor is 29.326%, less than 40%. Therefore, there is no serious common method bias in this study.

## Relationship between BIM-based Digital Transformation and Service Innovation Performance

In order to test whether BIM based digital transformation has a direct impact on service innovation performance and the direction of the impact relationship, this study uses BIM based digital transformation as the independent variable and service innovation performance as the dependent variable to build a "BIM based digital transformation -- service innovation performance" model, which is tested through the structural equation model. From the fitting index of the model, CMIN/DF=1.135 ≤ 3, GFI=0.905>0.8; AGFI=0.889>0.8; PGFI=0.769>0.05; NFI=0.913>0.8; IFI=0.989>0.8; CFI=0.989>0.8; TLI=0.988>0.8; RMSEA=0.022<0.08, which meets the requirements of the test standard, then the model can be used for hypopaper testing. The summary of model inspection results is shown in Table 5. From the table, it can be concluded that at the significance level of 0.1%, when only digital transformation and service innovation performance are available, BIM based digital transformation has a positive significant impact on service innovation performance, with the effect size of 0.646. Therefore, H1 verification has been completed.

**Table 3 Hypopaper Test Results (H1)**

| Variables and relations | HYP | β | P | Result | Conclusion |
|---|---|---|---|---|---|
| BIM-based digital transformation is positively correlated with service innovation performance of construction enterprises in the Yangtze River Delta. | H1 | C=0.646 | *** | Significant positive effect | Supported |

Note: ***p＜0.001, **p＜0.01, *p＜0.05 (two-tailed test).
(Source: Author)

## Relationship between Policy Orientation and Technological Innovation

This study uses BIM based digital transformation as the explanatory variable and business model as the explanatory variable, and uses AMOS17.0 to test the relationship hypopaper.

From the fitting index of the model, CMIN/DF=1.326 ≤ 3, GFI=0.902>0.8; AGFI=0.884>0.8; PGFI=0.760>0.05; NFI=0.910~0.8; IFI=0; CFI=0.976>0.8; TLI=0.974>0.8; RMSEA=0.034<0.08, the above values all meet the requirements of the test standard, and the model can be used for hypopaper testing. This study uses business model as the explanatory variable, and service innovation performance as the explanatory variable. It applies AMOS17.0 to test the relationship hypopaper. From the fitting index of the model, CMIN/DF=1.399<3, GFI=0.918>0.8; AGFI=0.897>0.8; PGFI=0.729>0.05; NFI=0.927>0.8; IFI=0.978>0.8; CFI=0.978>0.8; TLI=0.974>0.8; RMSEA=0.038~0.08, the above values meet the requirements of the inspection standard, and the model can be used for hypopaper testing. After testing H2a and H2b, it is found that the two standardized regional coefficients are significant. Then, the significance of coefficient c is tested according to Wen Zhonglin's Mediating effect analysis program based on Bootstrap method. Then, according to Wen Zhonglin's Mediating effect analysis program based on Bootstrap method, the next step is to test the significance of coefficient c. For this reason, this research takes BIM based digital transformation as the explanatory variable, service innovation performance as the explanatory variable, and business model as the mediator to build a "BIM based digital transformation business model service innovation performance" model. In this study, AMOS17.0 was used for mediating effect test, and the number of samples was set to 5000, and the deviation correction interval was set to 95%. From the fitting index of the model, CMIN/DF=1.2403; GFI=0.867>0.8; AGFI=0.849>0.8; PGFI=0.766>0.05; NFI=0.879>0.8; IFI=0.974>0.8; CFI=0.974>0.8; TLI=0.972>0.8; RMSEA=0.029<0.08; The above data all meet the requirements of the test standards, and the model can be used for hypopaper testing. The summary of model test results is shown in Table 6.

**Table 4 Test Results of Mediating Effect of Business Model**

| HYP | Variables and relations | β | 95% confidence interval | Results |
|---|---|---|---|---|
| H2 | BIM-based digital transformation--business model | a=0.612*** | [0.474,0.735] | Coefficients a and b have the same sign as c, and partial mediating effect exists |
| | Business model - Service innovation performance | b=0.461*** | [0.267,0.637] | |
| | BIM-based digital transformation - Service innovation performance | c=0.371*** | [0.184,0.547] | |
| | BIM-based digital transformation - Business model - Service innovation performance | c=a*b+c=0.612* 0.461+0.371 =0.6531 | Confidence interval for a*b [0.166,0.432] | H2 was supported, and the business model played a mediating effect of 43.19% |

Note: ***p<0.001, **p<0.01, *p<0.05 (two-tailed test); a, b and c in the table are the coefficient values under the influence of mediator.
(Source: Author)

The model test results are summarized as shown in Table 7. From the table, it can be concluded that at the significance level of 0.1%, only BIM based Digital Transformation and the business model, BIM based digital transformation has a positive significant impact on the business model, with the effect size of 0.561. Therefore, H2a validation has been completed.

**Table 5 Hypopaper Test Results (H2a)**

| Variables and relations | HYP | β | P | Result | Conclusion |
|---|---|---|---|---|---|
| BIM-based digital transformation is positively correlated with business model. | H2a | C=0.561 | *** | Significant positive effect | Supported |

Note: ***p＜0.001, **p＜0.01, *p＜0.05 (two-tailed test).
(Source: Author)

The model test results are summarized as shown in Table 8. From the table, it can be concluded that at the significance level of 0.1%, when only business model and service innovation performance are available, business model has a positive significant impact on service innovation performance, with the effect size of 0.679. Therefore, H2b verification has been completed.

**Table 6 Hypopaper Test Results (H2b)**

| Variables and relations | HYP | β | P | Result | Conclusion |
|---|---|---|---|---|---|
| Business model is positively correlated with service innovation performance of construction enterprises in the Yangtze River Delta. | H2b | C=0.479 | *** | Significant positive effect | Supported |

Note: ***p＜0.001, **p＜0.01, *p＜0.05 (two-tailed test).
(Source: Author)

Based on the above analysis, it can be found that H2a and H2b are supported, and H2 is supported.

**Relationship between Government Subsidies and Enterprise Performance**

In this study, the cross-multiplying items of environmental dynamics and BIM based digital transformation (i.e., the first half of modeling effect interaction item 1) and the cross-multiplying items of environmental dynamics and business model (i.e., the second half of modeling effect interaction item 2) are added to the benchmark model at the same time to judge the modeling effect of environmental dynamics. The model verification is carried out by using Mplus software programming, the model estimation method is the maximum likelihood correction method, and the Bootstrap is executed 2000 times. The model test results of adding two interaction items at the same time show that interaction item 1, namely the modeling effect of environmental dynamics and BIM based digital transformation on the business model, has a standardized path coefficient of 0.131, a p-value of 0.057>0.05, a non-standard path coefficient of 0.127, and a p-value of 0.062>0.05. Therefore, the modeling effect of environmental dynamics on the relationship between BIM based digital transformation and business model is not significant. Environmental dynamics has no significant effect on service innovation performance by adjusting the action path of BIM based digital transformation and business model. While interaction item 2 is the modeling effect of environmental dynamics in the process of business model's impact on service innovation performance, the standardized path coefficient is 0.500, the p-value is<0.001, and the non-standard path coefficient is 0.713, the p-value is<0.001. It shows that environmental dynamics has significant modeling effect in the process of business model influencing service innovation performance. In order to further analyze the modeling effect of environmental dynamics on business model and service innovation performance, only the interaction items between environmental dynamics and business model are included in the benchmark model for inspection. The model test results of only environmental dynamics and business model interaction items show that the interaction items and environmental dynamics have significant modeling effect in the process of business model's impact on service innovation performance, the standardized path coefficient is 0.782, p value<0.001, the non-standard path coefficient is 0.796, p value<0.001, and the AIC value of the model is 20067.834, and the BIC value is 20516.809. Compared with the benchmark model (AIC value is 20117.356, BIC value is 20560.462), it is lower, which indicates that the inclusion of interaction items makes the model fit better. Therefore, environmental dynamics has a significant modeling effect on business model and service innovation performance. The 95% deviation correction Bootstrap confidence interval is reported. The confidence interval of the interaction term is [0.546, 1.046], excluding 0, indicating that the mediating effect is significant. In addition, in order to further analyze the modeling effect of environmental dynamics on business model and service innovation performance, this study divides environmental dynamics into two groups: high group (M+1SD) and low group (M-1SD), and conducts a simple slope test of environmental dynamics on business model and service innovation performance. The test results show that in the high grouping (M+1SD), environmental dynamics has a significant positive modeling effect on the relationship between business model and service innovation performance (simple slope is 1.148, $p<0.001$), and the confidence interval is [0.835, 1.148]. If there is no 0, there is a significant moderating effect; In the low group (M-1SD), environmental dynamics has a negative modeling effect on the relationship between business model and service innovation performance (simple slope is -0.444, $p=0.008<0.05$), and the confidence interval is [-0.775, -0.114], indicating that the mediating effect is significant. The above results show that the moderating effect of environmental dynamics in the relationship between business model and service innovation performance is significant. From its standardized path coefficient, H3a is not supported, while H3b is supported, that is, H3 is partially supported. Table 9 shows the inspection results of H3.

**Table 7 Hypopaper Test Results (H3)**

| Variables and relations | HYP | β | P | Result | Conclusion |
|---|---|---|---|---|---|
| Environmental dynamics has a moderating effect in the relationship between BIM-based digital transformation and business model. | H3a | C=0.131 | *** | No significant positive effect | Not Supported |
| Environmental dynamics has a moderating effect in the relationship between business model and service innovation performance of construction enterprises in the Yangtze River Delta. | H3b | C=0.782 | *** | Significant positive effect | Supported |

Note: ***p＜0.001, **p＜0.01, *p＜0.05 (two-tailed test).
(Source: Author)

## Conclusion

The rapid development of digital economy and service economy has forced traditional industries to transform and upgrade. BIM based digital transformation is the main tool for the digital economy development of traditional construction enterprises, and service innovation is the development means for the service economy of traditional construction enterprises to keep pace with the times. The service innovation of construction enterprises accompanies the whole process of construction. BIM driven's information intensive integration of the whole process of construction breaks the traditional business organization structure and can effectively support the service innovation activities of construction enterprises, thus improving the service innovation performance of enterprises (Sun 2022). Guided by the cluster theory and continuity theory, this research constructs the theoretical model of BIM based digital transformation, business model and service innovation performance under environmental dynamics. This study puts forward research hypotheses through relationship discussion. Taking China's top 200 construction enterprises as the research object, the online and offline questionnaire survey method is used to collect data, and SPSS21.0, AMOS17.0 and MPLUS7.4 statistical analysis software are flexibly used to test the model. The test results show that BIM based digital transformation has a significant positive impact on service innovation performance, and business model plays a 43.19% part of the mediating effect in this relationship, while environmental dynamics has a significant modeling effect in the second half of the mediating relationship. In order to answer the three questions raised by the question analysis of this study, the main conclusions of this study are summarized from the following three items. First, BIM based digital transformation has a significant positive impact on service innovation performance. Both service innovation performance and BIM based digital transformation focus on customer value. Under the guidance of customer value as the core, BIM based digital transformation can improve the value of employees and customers through the shaping of digital culture, resource integration, process optimization, technical capability and customer relationships of construction enterprises. At the same time, it can also optimize the internal production and operation performance of the enterprise, obtain higher customer satisfaction and new customer volume, thus enhancing the market competitiveness and market share of the enterprise. Second, the business model plays a part of the mediating effect in the relationship between BIM based digital transformation and service innovation performance. BIM based digital transformation takes customer value as its core proposition, and reshapes each link of value provision, value creation and value capture in the business model value chain through corporate culture remodeling, resource allocation, process optimization, technical capability improvement, etc. The business model is a market value converter that converts inputs such as human resources, capital and materials into profits. BIM based digital transformation is customer value oriented, which can improve customer satisfaction and attract new customers. Value creation can optimize organizational processes, improve internal production efficiency and service levels, and thus affect the profit model and market structure of value capture (Hou 2021; Sun 2022). Third, environmental dynamics has a modeling effect on the second half of the relationship between BIM based digital transformation, business model and service innovation performance. The results of the latent adjustment structural equation model test show that the relationship between environmental dynamics and BIM based digital transformation and business model is not significant, while the relationship between environmental dynamics and business model and service innovation performance is significant. Environmental dynamics specifically include technology dynamics, demand dynamics and market dynamics (Ren & Xu 2022). Under the high environmental dynamics, the promotion and application policies of BIM technology and technology upgrading speed are fast. In order to adapt to the rapidly changing external technological environment and market environment, construction enterprises need to adjust and optimize the business model value chain in time according to their own characteristics and customer demand characteristics, so as to improve the value added of construction enterprises, improve the satisfaction of employees and customers, internal operation performance and market competitiveness. Under low environmental dynamics, new technologies emerge and update slowly, industry policy environment is relatively stable, customer demand and supply and demand relationship are stable, construction enterprises rely more on maintaining existing familiar and successful business models, and service innovation vitality is not high (Chen & Xu 2020).

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