SSRG International Journal of Civil Engineering
ISSN: 2348-8352/ https://doi.org/10.14445/23488352/IJCE-V11I7P105

Volume 11 Issue 7, 43-57, July 2024

Original Article

Explore the Influencing Factors of BIM Application in China

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Received: 11 May 2024 Revised: 10 June 2024 Accepted: 09 July 2024 Published: 31 July 2024

Abstract - *The construction industry has increasingly stringent requirements for project quality. Building Information Modeling (BIM) as a digital and informational tool for drawing and management in the construction sector has profoundly impacted the entire industry. Numerous researches have examined the factors influencing BIM development, yet variations exist across different Chinese provinces in terms of BIM technology adoption and development. Different factors affect the application of BIM in the construction industry of different provinces to varying degrees. Previous research in this field has primarily utilized questionnaire surveys and quantitative analysis methods. This research innovatively employs qualitative interviews as a research tool, through content analysis, it quantitatively synthesizes qualitative research to convert language into data. This approach enables a deeper exploration of the factors influencing BIM adoption in the construction industry of Henan Province. The results of the study include digitalisation, high-quality development, branding, corporate positioning, BIM approval system and other factors that have not been proposed in previous studies. This research not only addresses research gaps in Henan Province but also provides theoretical support for BIM development applicable to provinces with similar economic conditions in China.*

Keywords - *BIM, Interview, Content analysis, Construction industry, Influencing factors.*

1. Introduction

The construction industry, to adapt to the requirements of high-quality development, emerges more new organizational models and construction methods, which also require more and more architectural design aids. BIM technology for the construction industry puts forward a new design model and becomes a key tool which has a far-reaching impact on the industry as a whole [1, 2].

BIM serves as a centralized platform for project stakeholders, facilitating collaborative operations and communication. It integrates dispersed information from various time and location sources into a unified architectural information model, enabling design and construction discussions based directly on this model. This improves communication among multiple parties [3], ensuring synchronized communication and largely departing from traditional 2D operations [4, 5]. BIM can grasp the structure and effect of the project by using high-precision visualized 3D models [6, 7]. Improving design quality reduces the occurrence of design errors and clashes [8, 9].

The adoption rate of BIM in the Chinese construction industry has been increasing annually. Major cities such as Shenzhen, Shanghai and Beijing have achieved significant maturity in BIM implementation. But China is a country with 34 provinces, each with a different level of population, environment, economy and construction development. Many provinces lag behind these major cities in terms of BIM application. Henan Province is one of the 34 provinces in China, currently lags in BIM technology development compared to cities like Shenzhen and Shanghai. The factors affecting the development of BIM technology application in the construction industry in Henan Province have never been explored, which has a gap on how to develop BIM technology in the future of the construction industry in Henan Province, which also has a certain impact on improving the development of BIM technology in China.

Current research on factors influencing BIM adoption primarily focuses on China's major cities, and findings from these studies may not fully represent other provinces. Research methodologies often rely on questionnaire surveys, with the authenticity of collected responses not always realistic. Therefore, this study focuses on construction enterprises in Henan Province, employing an interview approach to delve deeper into the factors influencing BIM adoption. This study is significant as it not only provides data and theoretical support for the future development of BIM in the construction industry of Henan Province but also serves as a reference for neighboring provinces with similar economic profiles.

1.1. Aims and Significance of the Study

This research aims to investigate the influencing factors affecting the application of BIM in construction enterprises in Henan Province. This research is important because it provides data and theoretical support for the government of Henan Province to promote the development of BIM in the construction industry in the future; it also provides a reference basis for other provinces with similar economic levels.

2. Literature Review

2.1. Definition and Value of BIM

The idea of the Building Information Model (BIM) originated in the United States in the mid-1970s when Dr. Chuck Eastman proposed a computer simulation system for buildings [10, 11]. The Architecture Engineering and Construction (AEC) industry has been practically using BIM in construction projects since the mid-2000s [11, 12].

Finith E. Jernigan [13] suggests that BIM is based on a 3D geometric data model that brings together various types of special information about the physical information functional and characteristic needs of a building or structure and is based on certain standards that make information interoperability and sharing a reality. It is also a kind of knowledge resource that can be shared together, enabling the interoperability of information in all aspects of the whole construction process. Under the auspices of BIM, practitioners involved in the planning, design, implementation, operation and maintenance of a project can obtain the information they need.

This information is continuous, real-time, real, and unified for the whole construction, from the definition to the demolition of each link in each task and decision to provide an effective basis. BIM is also a kind of information technology means, its use can not be separated from the support of information technology tools. The implementation of the project in all periods of time can be used to obtain information from the model with the help of the BIM program and to carry out the use and processing and then the processed data back into the model to support and reflect the responsibility of all parties to collaborate.

2.2. Influencing Factors of BIM Adoption in China's Construction Industry

The factors affecting the application of BIM in the Chinese construction industry, as derived from the relevant literature, are discussed in five main categories: organization, environment, economy, technology, and personnel.

Organizational factors encompass policies issued by the government, governmental support for BIM adoption in the construction industry and enterprise scale. Policies and standards, governmental subsidies or mandatory requirements exert significant influence on BIM [14-17]. In recent years, many BIM applications in construction have been funded by the government or involved in tendering processes, positively impacting the utilization rate of BIM [14-20]. The importance of Small and Medium-sized Enterprises (SMEs) in China's economic development cannot be overlooked [18].

Environmental factors include market demand, owners' demand, management understanding of BIM, and formulation of internal organizational policies. The demand in the market driven by architectural enterprises seeking more contracts, is a critical factor influencing BIM adoption [14-17]. Past research confirms the pivotal role of clients in advancing the use of BIM [19]. Support from architectural enterprise management is also a crucial prerequisite for BIM adoption [20].

Previous research suggests a positive correlation between resource allocation for BIM and efforts made by architectural enterprise management; inadequate understanding of BIM at the managerial level hinders its comprehensive application, leading to a lack of awareness among staff regarding the necessity of BIM, thus influencing the adoption behavior [3]. The formulation of internal organizational policies also impacts BIM adoption in the construction industry [16]. These policies, including incentive and mandatory policies, affect the attitudes of architectural enterprise technical personnel towards BIM, significantly influencing behavioral intentions towards BIM application [22].

Economic factors encompass costs of software and upgrades, talent development, economic benefits, initial investment costs, etc. [16, 17]. Zhang R et al. [16] highlight that training for BIM personnel has the greatest impact on BIM adoption in architectural enterprises, underscoring the critical need for early investment in talent development. Furthermore, significant financial investment is required for software purchases and subsequent upgrades, deterring some enterprises from risk-taking and thereby affecting BIM application [16, 23]. Economic benefits are also crucial; BIM technology imposes high demands on computer hardware and software, necessitating substantial initial investment with unclear short-term returns [17]. Consequently, many small and medium-sized architectural enterprises are reluctant to invest heavily in BIM, fearing project risks and thus refraining from action [16].

Technological factors include employee capabilities, the collaborative nature of BIM, the complexity of BIM software, the presence of specialized BIM teams, the capabilities of professional graduates, and the degree of localization of BIM software. Designers within architectural enterprises are identified as the primary users of BIM [6, 24]; employee capabilities directly influence BIM adoption in architectural enterprises. Interdepartmental collaboration levels also significantly influence BIM application within architectural enterprises [20, 18].

BIM constitutes a technological system rather than a simple software or model [6]; the complexity of BIM software concerns architectural enterprise management [25]. Li Y et al. [26] emphasize the importance of recruiting professional graduates, particularly those skilled in BIM application and construction drawing design, to address talent shortages. Lastly, the degree of localization of Chinese BIM software influences its application in China [9, 24, 26].

Personnel factors include architect acceptance intentions and understanding of BIM architect with high motivation and BIM capabilities are more likely to use BIM [6]. Learning situations of enterprise employees also influence architect acceptance of BIM [9].

3. Methodology

Most of the past research exploring the influencing factors of BIM application in China used questionnaire surveys and quantitative analysis of data. This research used a combination of interviews and qualitative methods to study the influencing factors at a deeper level.

Qualitative research refers to a comprehensive study of social phenomena. It primarily employs inductive analysis to examine data and form theories, aiming to achieve an interpretative understanding of behaviors and meanings constructed through interaction with research subjects. Its notable strength lies in investigating phenomena characterized by dynamic transformations, interactions with and semantic diversity among researched subjects. Qualitative research is relatively adept at deriving interpretative conclusions or understanding specific phenomena, uncovering deeper insights from multiple perspectives [27, 28].

Initially, this study will identify a novel and scholarly research topic and object through a literature review. Subsequently, a semi-structured interview guide will be developed, and interviews with selected subjects will be conducted. Following the interviews, NVivo12 software will be used to organize and classify the raw data. The obtained results will be compared with existing research to validate conclusions. Ultimately, this process aims to explore the influencing factors in the construction industry of Henan Province.

3.1. Interview Credibility

Interview validity refers to the extent to which the interview measures what the interview study is intended to measure. The validity of an interview is affected by bias from various sources, including the validity of the interview questions, whether the substance of the interview questions covers the information to be collected in the interview study, whether the respondent accurately understands the interview questions and expresses views on the interview questions completely and honestly, and whether the interviewer accurately and completely expresses the interview questions and records the interviewer's responses without bias.

To improve the validity of the interviews, it is important to minimise interview bias, which can be achieved by accurate sample selection, accurate design of the interview outline, not changing the order of the questions, not being misinterpreted by what the interviewee says, expressing the questions clearly to the interviewee, and not asking targeted or biased follow-up questions in the course of the interview [29, 30].

Interview credibility refers to the extent to which the information obtained from an interview is reliable or can be relied upon. It is argued that one way to ensure credibility is to be consistent in wording when interacting with different interviewees. Changes in wording, context and focus of questions during an interview can erode credibility. Therefore, interview credibility can be improved by careful scheduling of interviews and consistent coding of interview data [29, 30].

3.2. Selection of the Interview Sample

According to Guest, Bunce and Johnson in their study How Many Interviews Are Enough? [31] systematically examined the relationship between sample size and data saturation in qualitative research, providing strong support for recommending the use of 8 to 12 participants in qualitative research. In this study, they used in-depth interviews on a variety of topics and monitored the emergence of new themes and found that data saturation was usually reached with the first 12 participants, after which very little new information emerged. Whilst recognising that this number may vary depending on the context and themes of the study, they concluded that 12 interviews may be sufficient to achieve data saturation in most cases.

In this research, 12 architectural enterprises are selected. Based on the research on the differences in the application of BIM in small and medium-sized construction enterprises in previous studies, 6 are large-scale architectural enterprises, and 6 are small and medium-sized enterprises in Henan Province. All of these enterprises are engaged in the business of architectural design at an early stage and have great influence and professional staff working with BIM.

3.3. Design of Interview Questionnaire

Interviews are used to uncover deeper results through interactive transcripts [32]. Semi-structured interviews are used by the interviewer to achieve the purpose of the study through a pre-designed outline, as well as by asking questions that jump out of the interview outline based on the data answered by different respondents [32].

Table 1. Summary of statistical information on respondents

No	Scale of construction enterprises	Years of BIM application	Respondent's position
1	Large scale Enterprises	10	BIM Team Leader
2	Large scale Enterprises	12	Head of BIM Center
3	Large scale Enterprises	7	BIM Center Staff
4	Large scale Enterprises	16	Head of BIM Center
5	Large scale Enterprises	13	Head of BIM Center
6	Large scale Enterprises	10	Head of BIM Center
7	Small and Medium-Sized Enterprises	9	BIM Center Staff
8	Small and Medium-Sized Enterprises	3	BIM Center Staff
9	Small and Medium-Sized Enterprises	5	BIM Center Staff
10	Small and Medium-Sized Enterprises	1	BIM Technician
11	Small and Medium-Sized Enterprises	1	Chief Technical Officer of the Company
12	Small and Medium-Sized Enterprises	1	BIM Technician

The design of interview guidelines begins with determining the topics covered by the interviews. Identifying the data needed from the interviews helps steer the direction of the study. Various factors identified in the literature review serve as the theoretical framework for this study, with more detailed topics outlined.

Identify the purpose of the inquiry behind each question. In the process of conducting semi-structured interviews with BIM practitioners in construction firms, an interview outline was developed based on a literature review, and six major themes were established, as shown in the table.

Table 2. Interview questions and objectives

No	Question	Purpose	Thematic
1	Can you define BIM?	Cognition	Personnel Factor
2	Do you think BIM is a successful CAD replacement technology, and why?	Degree of Acceptance	
3	What do you think is the best feature of BIM?	Point of View	
4	Do you think national policies have an impact on BIM practice adoption and implementation?	Point of View	Organizational Factor
5	What are your opinions and suggestions for improving the national BIM policy?	Point of View	
6	How does BIM change the structure and organisation of your company?	Exploring Reality	Environmental Factor
7	What has the company done to support the usage of BIM in the company? What else should the company do to provide enough support?	Point of View	
8	What do you think is the impact of owner requirements on BIM application?	Point of View	
9	How do the industry and market demand your company to choose to adopt BIM?	Point of View	

10	How significant is the benefit and return of investment that BIM drought to your company?	Point of view	Economic Factor
11	What is your opinion on the notion that the cost of BIM is a hindrance to adoption?	Point of view	
12	Do you think the multi-party collaboration of BIM is difficult to achieve, and what steps have your team taken to collaborate with other consultants using BIM?	Exploring Realities and Perspectives	Technical factor
13	What is your view of the learning current of BIM?	Point of view	
14	Based on your experience, how competent are the professional graduates available in the market in terms of BIM proficiency?	Exploring Realities and Perspectives	
15	What do you think of BIM localization software in the market?	Exploring Realities and Perspectives	
16	In your opinion, what are the top 3 drivers that can promote the adoption of BIM in Henan?	Point of View	Open topic
17	In Henan, What type of external organisation is best to help increase BIM adoption, and how can they do that?	Point of View	

Table 3. Factor decoding table

Influencing Factors	Impact Factor Coding
Visualization	1-1-1,1-3-1,1-4-1 1-7-1,1-8-1,1-9-1
Data Analytics	1-1-2,1-3-2,1-4-2 1-7-2,1-8-2,1-9-2
Digital Development	1-2-1,1-6-1,1-10-1 1-12-1
Project Management Tools	1-11-1
Dynamically Updated Data	1-6-2,1-11-2

Table 4. Factor decoding table

Influencing Factors	Impact Factor Coding
CAD is Irreplaceable	2-1-1,2-2-1,2-3-1,2-4-1,2-5-1 2-6-1,2-7-1,2-8-1,2-9-1 2-10-1,2-11-1,2-12-1
Drawing the Way of Thinking	2-3-2,2-5-2,2-6-2
Long BIM Drawing Time	2-4-2,2-10-2,2-12-2
No Policy Requirement	2-9-2,2-7-2,2-10-3,2-11-2
Getting Used to CAD	2-1-2,2-3-3,2-4-3,2-6-3,2-7-3 2-8-2,2-9-2,2-10-4

3.4. Content Analysis Method

Content analysis is a quantitative analysis method based on qualitative research, which can transform linguistic documents into data and express the results of the analysis with statistics [33][33]. Each item was decoded according to the topics in the interview outline, and the influencing factors that emerged were coded; a code of 1-1-1 would indicate the first factor coded by respondent 1 in question 1 of the interview outline.

4. Findings and Analysis

4.1. Interview Text Analysis Decoding

4.1.1. Can you Define BIM?

Regarding the understanding of BIM, 6 respondents indicated that BIM is an upgrade from 2D to 3D, which allows for a better visual representation of the building design and the use of the model to analyze the data; 4 respondents indicated that BIM is a product of digital development, 2 respondents indicated that BIM is a platform based on the collection of data that allows for dynamic updating of the data, and 1 respondent indicated that BIM is a systematic project management tool.

4.1.2. Do You Think BIM is a Successful CAD Replacement Technology, and Why?

12 interviewees believe that although BIM has many advantages, in the short term, BIM can not replace CAD; 3 interviewees think the traditional thinking of drawing can not be changed in the short term, 3 interviewees said that many construction projects have a short construction period if the use of BIM can not able to submit the results of the agreed period of time; 8 interviewees said that the use of CAD habit cannot be changed; 4 interviewees said that BIM is not mandatory in national policy, so many enterprises still choose CAD; 4 interviewees suggested that BIM is a complex and multi-disciplinary software, which requires architects to spend a lot of time to learn, most architects are not willing to try the

challenge. 4 interviewees think that BIM can replace CAD only if architectural enterprises completely abandon CAD.

4.1.3. What do you Think is the Best Feature of BIM?

All 6 respondents mentioned visualization, three mentioned synergy, one mentioned data, and two mentioned collision checking.

Table 5. Factor decoding table

Influencing Factors	Impact Factor Coding
Visualization	3-1-1,3-4-1,3-6-1,3-8-1 3-10-1,3-11-1
Collaboration	3-2-1,3-5-1,3-12-1
Collision Checking	3-7-1,3-9-1
Datability	3-3-1

Table 6. Factor decoding table

Influencing Factors	Impact Factor Coding
Mandatory Policies	4-1-1,4-2-1,4-3-1,4-4-1 4-5-1,4-6-1 ,4-7-1,4-8-1 4-9-1, 4-10-1,4-11-1,4-12-1
Incentive Policy	4-7-2,4-9-2,4-10-2,4-11-2
Guidance Policy	4-1-2,4-3-2,4-8-2,4-10-3 4-11-3,4-12-2
Enterprise Size	4-7-3,4-9-3,4-10-3,4-11-3

4.1.4. Do You Think National Policies have an Impact on BIM Practice Adoption and Implementation?

All of the respondents affirmed the impact of mandatory policies on BIM, and 4 SMEs respondents suggested that incentive policies have a positive effect on promoting the application of BIM in enterprises. When asked whether some of the guiding policies issued by Henan Province have a role to play in the application of BIM in enterprises, half of the respondents said no, it can only enable more enterprises to recognize BIM.

4.1.5. What are Your Opinions and Suggestions for Improving the National BIM Policy?

This answer shows diversified results; 6 respondents expressed the government can improve the BIM standard; and 5 respondents believed that more policies should be introduced on the BIM approval system.

Only when BIM is included in the approval process will more construction enterprises adopt it to facilitate audits. 3 respondents believed that if BIM technology has a recognition system, then it will promote more.

2 interviewees suggested that the state can use the policy to promote the domestic software, and only if the enterprises really apply the domestic software can the BIM technology be better developed; 5 SME interviewees hoped that the government could introduce incentives to support SMEs to develop BIM.

Table 7. Factor decoding table

Influencing Factors	Impact Factor Coding
Clarify the Period of Work in the Policy	5-11-1
BIM Approval System	5-3-2,5-6-2,5-9-1,5-10-1,5-12-2
BIM Technology Recognition System	5-5-1,5-7-2,5-9-2
Introduce the BIM Software Promotion Policy	5-2-1,5-3-1
Small and Medium-Sized Enterprise Support Policy	5-6-3,5-7-3,5-9-3,5-10-2 5-11-2,5-12-3

4.1.6. How does BIM Change the Structure and Organisation of Your Company?

All large construction enterprises have set up BIM departments; there are 2 large enterprises to form a multi-departmental synergy of the three-tier organizational structure model.

The BIM team of each design institute is responsible for the collaboration of various specialities after the program is determined, and finally, the construction stage sets up the management personnel with BIM knowledge to guide the on-site construction for the landing of the BIM project; only one of the SMEs has set up a BIM center, and the remaining 5 SMEs are only part-time architects with BIM personnel.

Table 8. Factor decoding table

Influencing Factors	Impact Factor Coding
With BIM Team	6-1-1,6-2-1,6-3-1,6-4-1,6-5-16-6-1,6-9-1,
Without BIM Team	6-7-1,6-8-1,6-10-1,6-11-1 6-12-1
Enterprise Size	6-7-2,6-8-2,6-10-2,6-11-2 6-12-2

4.1.7. What has the Company Done to Support the Usage of BIM in the Company? What else should the Company do to Provide Enough Support?

8 enterprises organize regular training to support BIM technology development, 4 enterprises use awards to support projects using BIM on top of regular training, and 2 enterprises propose regular BIM competency tests for employees as well as internal BIM technology competitions.

Four SMEs do not have any measures to support BIM development because of the part-time BIM staff of their architects. When asked what kind of support employees expect from the organization for BIM development, all respondents thought that bonuses or job promotions would be the most effective in getting people to apply for BIM.

Table 9. Factor decoding table

Influencing Factors	Impact Factor Coding
Regular Training	7-1-1,7-2-1,7-3-1,7-4-1,7-5-1 7-6-1,7-7-1,7-9-1
Establishment of BIM Awards	7-2-2,7-4-2,7-5-2,7-6-2
BIM Technology Competition	7-1-2,7-3-2
Enterprise Size	7-8-1,7-10-1,7-11-1,7-12-1

Table 10. Factor decoding table

Influencing Factors	Impact Factor Coding
Satisfying the Owner's Demands	8-1-1,8-2-1,8-3-1,8-4-1,8-5-1,8-6-1,8-7-1,8-8-1,8-9-1, 8-10-1,8-11-1,8-12-1
Influencing Project Contract Requirements	8-2-2,8-3-2,8-6-2,8-10-2,8-12-2
Owner Knowledge of BIM	8-1-2,8-4-2,8-5-2,8-6-3,8-12-3

Table 11. Factor decoding table

Influencing Factors	Impact Factor Coding
Enhancing Competitiveness	9-3-3,9-4-3,9-10-3
Build a Brand	9-4-4,9-7-2,9-9-3
Project Type and Difficulty	9-1-3,9-2-3,9-5-3,9-9-4,9-10-4
Digital Development	9-1-1,9-2-1,9-3-1,9-4-1,9-5-1,9-6-1,9-9-1,9-10-1
High-Quality Development	9-1-2,9-2-2,9-3-2,9-4-2,9-5-2,9-6-2,9-9-2,9-10-2

Table 12. Factor decoding table

Influencing Factors	Impact Factor Coding
Long Return Cycle	10-1-1,10-2-1,10-3-1,10-4-1 10-6-1
Build a Brand	10-1-4,10-2-4,10-3-4,10-5-1 10-9-1
Post-construction Cost Savings	10-1-3,10-2-3,10-3-3,10-4-3 10-6-3
Saving Construction Time	10-1-2,10-2-2,10-3-2,10-4-2 10-6-2
Satisfy the Owner's Demand	10-8-1,10-9-2,10-10-1 10-11-1,10-12-1

4.1.8. What Do You Think is the Impact of Owner Requirements on BIM Application?

All of them believe that the owner has absolute influence on the application of BIM. If the owner proposes the application of BIM in the project, the construction enterprises will try to fulfill it as much as possible. Suppose the owner asks for BIM to be included in the contract requirements. In that case, the construction enterprises will try to fulfill it even if they are not sufficiently competent in BIM. 5 interviewees said that the owner's awareness of BIM is also very important, which determines the value of the application of BIM.

4.1.9. How Do the Industry and Market Demand Your Company to Choose to Adopt BIM?

6 large enterprises said that due to the high quality of construction and the trend of digital development, construction enterprises have to apply BIM; 3 enterprises said that in order to win the bidding competition for large-scale projects, construction enterprises also apply BIM;5 enterprises interviewed this time started to introduce BIM before it was widely promoted, and interviewees said that this was because managers hoped that BIM could enhance the company's brand in the market, 5 enterprises think that with the characteristics of the project, although some projects do not have the market requirements if the project is difficult, they will also use BIM.

4.1.10. How Significant is the Benefit and Return of Investment that BIM Drought to Your Company?

All the enterprises think that economic benefits and return on investment are very important, but five of them often take EPC projects. These enterprises think that although they can't see the return on the use of BIM in the early stage, the cost saving and shortening of construction period in the construction stage are enough to make the enterprises continue applying BIM; 5 enterprises expressed their recognition of the brand of the enterprise after using BIM which will also let managers see the return on investing in BIM.

However, for the 4 SMEs, the effect of applying BIM is not very satisfactory because some of them just use BIM visualization to meet the owner's demand, and the owner doesn't increase the design fee because of this, so the economic benefits and returns are not obvious.

4.1.11. What is your Opinion on the Notion that the Cost of BIM is a Hindrance to Adoption?

For the issue of cost hindrance, 3 SMEs think that their enterprises have not received any BIM projects in the past two years, so for them the cost issue of BIM is a hindrance. However, for large enterprises, the cost is not the biggest hindrance; 3 interviewees proposed that the cost hindrance is because the enterprises don't have a clear position in the early stage of applying BIM.

Some enterprises do not have an in-depth application of BIM or lack of support from BIM talents, and the cost becomes an obstacle. 2 enterprises suggested that the application of BIM is only for the purpose of awarding prizes, so the cost will eventually become an obstacle and cannot support the long-term development of BIM technology in the enterprise.

Table 13. Factor decoding table

Influencing Factors	Impact Factor Coding
Number of Projects	11-8-1,11-11-1,11-12-1
Technical Support	11-5-3,11-7-1
Clear Positioning	11-2-1,11-3-1,11-5-1
Cost hindrance	11-8-2,11-11-2,11-12-2
Depth of Application	11-2-2,11-4-1,11-6-1
BIM Personnel	11-1-1,11-2-3,11-5-2
Award Demand	11-1-2,11-9-1,11-10-1
enterprise Size	11-8-2,11-11-3,11-12-3

Table 13. Factor decoding table

Influencing Factors	Impact Factor Coding
Synergy	12-1-1,12-2-1,12-3-1,12-4-1 12-5-1,12-6-1,12-9-1
Difficulty of Communication	12-7-1,12-8-1,12-10-1, 12-11-1,12-12-1

4.1.12. Do You Think the Multi-Party Collaboration of BIM is Difficult to Achieve, and What Steps have Your Team Taken to Collaborate with Other Consultants Using BIM?

All the large enterprises interviewed think that professional collaboration is not difficult at present because large construction enterprises already have collaboration platforms; all BIM projects based on the platforms reduce the complexity of internal collaboration. It is not difficult to realize cooperation with external enterprises as long as they keep communicating during the project.

For small and medium-sized enterprises that have not set up a BIM team, the interviewees suggested that there are still differences in the work patterns of various professions, which need to be communicated well in advance, but due to the lack of conditions for purchasing a collaboration platform, it is still a difficult point if BIM is applied in the long term.

4.1.13. What is Your View of the Learning Current of BIM?

All of the interviewees think that the current atmosphere of learning BIM is not optimistic. 5 interviewees said that the time architects spend on learning BIM is not proportional to the final gain, 3 interviewees said that although the company requires all staff to learn BIM, the main training resources are still tilted to the BIM team, there is no opportunity to learn BIM, 3 interviewees said that even though they know BIM, they are still more used to CAD, 7 interviewees said that there is no mandatory requirement for designers in departments other than the BIM team, so many designers choose not to learn.

5 interviewees are only applying BIM very simple technology to their current projects, but BIM is software that involves a wide range of specialized software, and there is no place for learning the complex technology in BIM, so the learning of BIM is not so profound; 2 respondents said that young people are more enthusiastic in learning BIM.

Table 15. Factor decoding table

Influencing Factors	Impact Factor Coding
No in-Enterprise Pressure	13-1-1,13-2-1,13-4-1,13-5-1 13-10-1,13-11-1,13-12-1
Low Return on Learning	13-1-3,13-4-3,13-8-1,13-9-3
Uneven Training Resources	13-6-1,13-12-2
Habitual CAD	13-1-4,13-8-2,13-10-2
In-Depth Learning	13-9-2
Low Industry Demand	13-4-2,13-5-2,13-7-1,13-9-1,13-12-3
Youthfulness	13-1-2,13-3-1

Table 16. Factor decoding table

Influencing Factors	Impact Factor Coding
Single Competency	14-2-1,14-3-1,14-4-1,14-6-2 14-8-1,14-10-1,14-11-1
Able to Operate BIM Skillfully	14-1-1,14-5-1,14-6-1,14-7-1,14-9-1,14-12-1
Weak Practical Ability	14-1-2,14-3-3,14-6-3,14-8-2 14-9-2,14-12-2

Table 17. Factor decoding table

Influencing Factors	Impact Factor Coding
Auxiliary Software Mostly	15-1-1,15-8-1,15-5-1,15-12-1
No Substitute for Foreign Software	15-2-2,15-3-1,15-4-1,15-7-1 15-9-1,15-11-1
Software Promotion	15-6-1,15-10-2

4.1.14. Based on Your Experience, How Competent are the Professional Graduates Available in the Market in Terms of BIM Proficiency?

All respondents said that graduates have no problem with BIM operation ability, but the ability is too single, just know how to use BIM software, so graduates still need time to accumulate experience for companies to become a BIM talent.

4.1.15. What Do You Think of BIM Localization Software in the Market ?

All interviewees said that domestically developed BIM software cannot replace foreign software, most localized software is only based on plug-ins of foreign software and cannot completely replace foreign software; 2 interviewees said that localized software still needs to be promoted.

4.1.16. In Your Opinion, What are the Top 3 Drivers that can Promote the Adoption of BIM in Henan?

Statistical respondents answered that the largest proportion of factors is the policy following considerations from the construction enterprise itself, to increase the competitiveness of the enterprise is ranked second, and the third factor is mainly embodied in the report of awards, to enhance the value of the enterprise's reputation and so on, the market demand and improve the quality of the project, the

economic returns, corporate support. Digital development, market demand, corporate positioning, BIM talent, and so on also have a certain impact on the application of BIM.

Table 18. Factor decoding table

Influencing Factors	Impact Factor Coding
Senior Management Support	16-1-1,16-4-1
Value of BIM	16-1-2,16-5-1,16-6-1
Economic Returns	16-1-3,16-3-2,16-8-2
Policies	16-2-1,16-4-2,16-5-2,16-8-1,16-9-1,16-10-1,16-11-2,16-12-1
Contract Requirements	16-2-2
Cost Reduction and Efficiency	16-2-3,16-12-3
Input Costs	16-3-1
Enhancing Competitiveness	16-3-3,16-5-3,16-7-1,16-10-2
Digital Development	16-4-3
Data Shareability	16-6-2
Improve Project Quality	16-6-3,16-7-2,16-10-3
Brand Promotion	16-7-3
Used by all Partner Companies	16-8-3
Enterprise Development Positioning	16-9-2
BIM Personnel	16-9-3
Localized Software Development	16-11-1
Return on Investment	16-11-3

4.1.17. In Henan, What Type of External Organisation is Best to Help Increase BIM Adoption, and How can They Do that?

Some enterprises believe that implementing BIM effectively involves integrating BIM departments with other professional departments to bridge significant revenue gaps. This integration could reduce rapid turnover within BIM departments, fostering a stable organizational environment.

Many enterprises emphasize the need for government and owner support in BIM technology development. They also highlight the importance of higher education in cultivating adequate BIM skills among graduates to meet industry demands. Respondents suggest that BIM managers should possess professional expertise in BIM to enhance both managerial and technical proficiency. They advocate for centralized government review to formulate effective policies and suggest rejuvenating organizational environments to align with digital advancements, appealing particularly to younger generations.

Table 18. Factor decoding table

Influencing Factors	Impact Factor Coding
Youthfulness	17-1-1,17-2-1
Recognition by Enterprise Leaders	17-1-2,17-3-1,17-4-1,17-5-2,17-7-1,17-8-1,17-10-2
Centralization of Power	17-2-2
Moderate Team Size	17-2-3
Workload is Supported within the Organization	17-3-2,17-8-2,17-9-2,17-12-1
Managers have Expertise in BIM	17-5-1
Government-LED	17-6-1,17-10-1
Owner-LED	17-6-2,17-7-2,17-11-1
No Quota Constraints	17-9-1
Owner Expertise	17-11-2,17-12-2
BIM Fee Standard	17-1-4,17-4-2

4.2. Statistical Analysis of Final Impact Factors

A total of 97 factors were formed, of which the number of counts reached 378, and the duplicates and factors with similar meanings were sorted out, resulting in 53 factors.

Table 19. Summary of factors in interview text

Influencing Factors	Impact Factor Coding	Reckoning	Percentage (%)
Mandatory and Incentive Policies	2-9-2,2-7-2,2-10-3,2-11-2,4-1-1,4-2-1,4-3-1,4-4-1,4-5-1,4-6-1,4-7-1,4-8-1,4-9-1,4-10-1,4-11-1,4-12-1,4-7-2,4-9-2,4-10-2,4-11-2,4-1-2,4-3-2,4-8-2,4-10-3,4-11-3,4-12-2 16-2-1,16-4-2,16-5-2,16-8-1,16-9-1,16-10-1,16-11-2 16-12-1	34	8.99
Satisfying Owners' Demands	8-1-1,8-2-1,8-3-1,8-4-1,8-5-1,8-6-1,8-7-1,8-8-1,8-9-1 8-10-1,8-11-1,8-12-1,9-7-1,9-8-1,9-11-1,9-12-1,10-8-1 10-9-2,10-10-1,10-11-1,10-12-1	21	5.56
Enterprise Size	4-7-3,4-9-3,4-10-3,4-11-3,6-7-2,6-8-2,6-10-2,6-11-2,6-12-2,7-8-1,7-10-1,7-11-1,7-12-1,10-8-2,10-10-2,10-11-2,10-12-2,11-8-2,11-11-3,11-12-3	20	5.29
Meeting Digital Development	1-2-1,1-6-1,1-10-1,1-12-1,9-1-1,9-2-1,9-3-1,9-4-1,9-5-1,9-6-1,9-9-1,9-10-1,16-4-3	13	3.44

BIM Team	6-1-1,6-2-1,6-3-1,6-4-1,6-5-1,6-6-1,6-9-1,6-7-1,6-8-1 6-10-1,6-11-1,6-12-1,17-2-3	13	3.44
3D Visualization	1-1-1,1-3-1,1-4-1,1-7-1,1-8-1,1-9-1,3-1-1,3-4-1,3-6-1 3-8-1,3-10-1,3-11-1	12	3.17
CAD irreplaceable	2-1-1,2-2-1,2-3-1,2-4-1,2-5-1,2-6-1,2-7-1,2-8-1,2-9-1, 2-10-1,2-11-1,2-12-1	12	3.17
High-Quality Development	9-1-2,9-2-2,9-3-2,9-4-2,9-5-2,9-6-2,9-9-2,9-10-2,16-6-3, 16-7-2,16-10-3	11	2.91
Getting used to CAD	2-1-2,2-3-3,2-4-3,2-6-3,2-7-3,2-8-2,2-9-2,2-10-4,13-1-4, 13-8-2,13-10-2	11	2.91
Datability	1-1-2,1-3-2,1-4-2,1-7-2,1-8-2,1-9-2,1-6-2,1-11-2,3-3-1, 16-6-2	10	2.65
Collaborative	3-2-1,3-5-1,3-12-1,12-1-1,12-2-1,12-3-1,12-4-1,12-5-1, 12-6-1,12-9-1	10	2.65
High Leadership Support	16-1-1,16-4-1,17-1-2,17-3-1,17-4-1,17-5-2,17-7-1 ,17-8-1,17-10-2,17-5-1	10	2.65
Building a Brand	9-4-4,9-7-2,9-9-3,10-1-4,10-2-4,10-3-4,10-5-1,10-9-1,16-7-3	9	2.38
Regular Training	7-1-1,7-2-1,7-3-1,7-4-1,7-5-1,7-6-1,7-7-1,7-9-1	8	2.12
Intra-Company Pressure	13-1-1-,13-2-1,13-4-1,13-5-1,13-10-1,13-11-1,13-12-1	7	1.85
Owner Professionalism	8-1-2,8-4-2,8-5-2,8-6-3,8-12-3,17-11-2,17-12-2	7	1.85
Increase Competitiveness	9-3-3,9-4-3,9-10-3,16-3-3,16-5-3,16-7-1,16-10-2	7	1.85
Single Capability	14-2-1,14-3-1,14-4-1,14-6-2,14-8-1,14-10-1,14-11-1	7	1.85
National Software Development	15-1-1,15-8-1,15-5-1,15-12-1,15-6-1,15-10-2,16-11-1	7	1.85
Unified BIM Standard	5-1-1,5-4-1,5-6-1,5-7-1,5-8-1,5-12-1	6	1.59
Small and Medium-Sized Enterprise Support Policy	5-6-3,5-7-3,5-9-3,5-10-2,5-11-2,5-12-3	6	1.59
Establishment of BIM Awards and Competitions	7-2-2,7-4-2,7-5-2,7-6-2,7-1-2,7-3-2	6	1.59
Project Contract Requirements	8-2-2,8-3-2,9-6-2,8-10-2,8-12-2,16-12-2	6	1.59
BIM Operational Ability	14-1-1,14-5-1,14-6-1,14-7-1,14-9-1,14-12-1	6	1.59
Practical Ability	14-1-2,14-3-3,14-6-3,14-8-2,14-9-2,14-12-2	6	1.59
Foreign Software Substitutability	15-2-2,15-3-1,15-4-1,15-7-1,15-9-1,15-11-1	6	1.59
Industry Demand	13-4-2,13-5-2,13-7-1,13-9-1,13-12-3,16-8-3	6	1.59
Economic Returns	16-1-3,16-3-2,16-8-2,16-11-3,16-2-3,16-12-3	6	1.59
Workload Supported by in-Enterprise	17-3-2,17-8-2,17-9-2,17-12-1,17-9-1	5	1.32
BIM Approval System	5-3-2,5-6-2,5-9-1,5-10-1,5-12-2	5	1.32
Project Type and Difficulty	9-1-3,9-2-3,9-5-3,9-9-4,9-10-4	5	1.32

Returns Cycle	10-1-1,10-2-1,10-3-1,10-4-1,10-6-1	5	1.32
Construction Cost Savings	10-1-3,10-2-3,10-3-3,10-4-3,10-6-3	5	1.32
Reduction of the Construction Period	10-1-2,10-2-2,10-3-2,10-4-2,10-6-2	5	1.32
Difficulty in Communication and Collaboration	12-7-1,12-8-1,12-10-1,12-11-1,12-12-1	5	1.32
Clarification of the Company's Position	11-2-1,11-3-1,11-5-1,16-9-2	4	1.06
Learning Returns	13-1-3,13-4-3,13-8-1,13-9-3	4	1.06
Youthfulness	13-1-2,13-3-1,17-1-1,17-2-1	4	1.06
BIM Technology Recognition System	5-5-1,5-7-2,5-9-2	3	0.79
Cost Hindrance	11-8-2,11-11-2,11-12-2	3	0.79
Depth of Application	11-2-2,11-4-1,11-6-1	3	0.79
Demand for Awards	11-1-2,11-9-1,11-10-1	3	0.79
Number of Projects	11-8-1,11-11-1,11-12-1	3	0.79
Value of BIM	16-1-2,16-5-1,16-6-1	3	0.79
Owner-LED	17-6-2,17-7-2,17-11-1	3	0.79
BIM Software Promotion Policy	5-2-1,5-3-1	2	0.53
Training Resources	13-6-1,13-12-2	2	0.53
Government-LED	17-6-1,17-10-1	2	0.53
BIM Fee Schedule	17-1-4,17-4-2	2	0.53
Project Management Tools	1-11-1	1	0.26
Learning Depth	13-9-2	1	0.26
Input Costs	16-3-1	1	0.26
Centralized Organizational Model	17-2-2	1	0.26

4.3. Discussion and Recommendations

The statistical analysis of the influencing factors shows that the top three factors influencing the application of BIM in the construction industry in Henan Province have been argued in the same way in the past studies, which indicates that there is consistency between the results of this study and the past studies. In addition to this, 18 other factors are the same as those in the past studies, as shown in Table 20.

This study explores the factors that have not been mentioned in previous studies in the construction industry in Henan Province, as shown in Table 21.

Table 20. Same factors as previous studies

No	Influencing Factors
1	Mandatory and Incentive Policies
2	Satisfying Owners' Demands
3	Enterprise Size
4	BIM Team
5	3D Visualization
6	Collaborative
7	High Leadership Support
8	Regular Training
9	Single Capability
10	National Software Development

11	Unified BIM Standard
12	Practical Ability
13	Economic Returns
14	Returns Cycle
15	Difficulty in Communication and Collaboration
16	Cost Hindrance
17	Value of BIM
18	Owner-LED
19	Government-LED

Table 21. Different factors as previous studies

No	Influencing Factors
1	Meeting Digital Development
2	CAD Irreplaceable
3	High-Quality Development
4	Getting used to CAD
5	Datability
6	Building a Brand
7	Intra-Company Pressure
8	Owner Professionalism
9	Increase Competitiveness
10	Small and Medium-Sized Enterprise Support Policy
11	Establishment of BIM Awards and Competitions
12	Project Contract Requirements
13	BIM Operational Ability
14	Foreign Software Substitutability
15	Industry Demand
16	Workload Supported by In-enterprise
17	BIM Approval System
18	Project Type and Difficulty
19	Construction Cost Savings
20	Reduction of Construction Period
21	Clarification of the Company's Position
22	Learning Returns
23	Youthfulness
24	BIM Technology Recognition System
25	Depth of Application
26	Demand for Awards
27	Number of Projects
28	BIM Software Promotion Policy
29	Training Resources
30	BIM Fee Schedule
31	Project Management Tools
32	Learning Depth
33	Input Costs
34	Centralized Organizational Model

Based on the analysis of the factors that have not appeared in previous research, it is summarized that the factors of the construction industry in Henan Province towards the application of BIM have the following characteristics:

Spontaneous drivers within the industry are more obvious in promoting the application of BIM in Henan Province. The planning and positioning of enterprises, branding and other factors account for a high proportion, which reflects the lack of incentives and mandatory measures in Henan Province; the development of the application of BIM in Henan Province by the construction industry to promote the reality of spontaneity is more prominent. The application of BIM in the construction industry is not limited to the government's incentives and mandatory policies for the release of BIM. There is also a need for the government to form a systematic set of policies for the implementation of BIM qualification and certification.

Although economic factors have a certain impact on the construction industry in China and Henan Province, but the construction industry in Henan is not the core of the leading factors. And the focus of the two is different. For example, past studies have emphasized the economic benefits of BIM for the Chinese construction industry, while Henan construction companies are more concerned about whether the application of BIM can increase the core competitiveness of construction companies or brand reputation.

The rapid development of digitalization has, to a certain extent, affected the construction industry in Henan Province, especially the small and medium-sized construction enterprises. Although some small and medium-sized construction enterprises in Henan Province have not formed a complete BIM organizational structure and have not realized the continuous application of BIM, when it comes to the future trend, the interviewees still said that because of the arrival of the digital era, the application of BIM in the future can be affirmed.

Architects' habit of using CAD has a greater impact on the application of BIM. This is an important factor for the unpromising atmosphere of BIM learning in architectural firms, a factor that has been mentioned but not really emphasized in the Chinese study. All the interviewees in this study raised the irreplaceability of CAD, and this factor will have an impact on the future of BIM in architectural firms as well as architects for a long time to come.

Based on the influencing factors of this study, it is suggested that the construction industry in Henan Province should better apply BIM in the future.

Policy support at the government level is a powerful guarantee for the application of BIM in construction enterprises. Henan provincial government should understand the actual difficulties and needs of different types of enterprises, and in the policy development of small and medium-sized construction enterprises to a certain degree of inclination. Guiding construction enterprises with low levels of BIM application and large construction enterprises to form one-to-one mutual assistance, clear support direction to

promote the uneven level of BIM in construction enterprises in Henan Province.

Enterprises in the process of applying BIM technology, to accurately position the application objectives and long-term planning for the future development of enterprises. Seize the opportunity to actively explore the strategies and modes of BIM technology application, seriously summarise the application experience of existing BIM projects, project construction and construction should be started as early as possible before the BIM work to reserve sufficient time for the contract delivery cycle, so as to be able to practically solve the problem of long duration of the project's complex BIM design, to ensure that the BIM is positively designed for the quality of the project to be added to the icing on the cake.

In the course of the interviews, it was found that architects need to have an adaptation phase during the change of thinking from 2D to 3D. Especially the 'old architects' who are used to the traditional 2D way of thinking is not easy to accept the 3D thinking mode of BIM. The change of thinking from 2D to 3D requires a change in the habit of using CAD. The problem of 'old architects' can be overcome by the drive of enterprises and their own practice. On the one hand, enterprises can arrange BIM training for 'old architects', which can let them learn 3D design and help them understand the 3D working mode; on the other hand, architectural enterprises should formulate incentives to motivate architects to accept to learn BIM or make use of BIM projects to formulate the BIM assessment mechanism to let the 'old architects' learn BIM by participating in BIM projects. On the other hand, architectural companies should formulate incentive policies to encourage architects to learn BIM or use BIM projects to develop BIM assessment mechanisms to enable 'old architects' to adapt to BIM technology through participation in BIM projects.

The integration of BIM technology with other innovative technologies is an important part of the multi-faceted innovation of BIM. The construction industry to meet digital development, should use BIM technology to keep pace with the times, technological innovation and technological interaction with the trend of information technology for the construction industry to provide opportunities for change.

5. Conclusion

This study employs qualitative analysis to conduct interviews with 12 construction enterprises in Henan Province that utilize BIM. Through content analysis, the study quantifies influencing factors from interview transcripts, transforming qualitative research into data and exploring underlying factors affecting BIM adoption in the construction industry of Henan Province. The practical significance of this research pertains to large and small-medium enterprises in Henan Province, reflecting the current state of BIM adoption in the construction industry and the experiences of BIM practitioners. It addresses gaps in Henan Province's understanding in this field, providing research support for BIM technology development and offering insights applicable to provinces with similar economic conditions.

The results of this study explore different influencing factors at a deeper level than previous studies and, at the same time, use data statistics to get the proportion of influence of each influencing factor on the application of BIM in the construction industry in Henan Province. From the results of the study, it can be concluded that the top 10 factors in terms of the degree of influence are Mandatory and Incentive Policies, Satisfying Owners' Demands, Enterprise Size, Meeting Digital Development, BIM Team, 3D Visualization, CAD irreplaceable, High-Quality Development, Getting used to CAD, Datability, Collaborative.

Based on the study findings, recommendations include the Henan provincial government focusing on current BIM adoption among construction enterprises, providing targeted support to the industry. Henan's construction enterprises should seize new opportunities in digital development, clarify their positioning and future development plans, and enhance owners' understanding of BIM to justify increased design fees for BIM's added value. The selection of representative areas to further study the factors affecting the application of BIM to fill the gap in the past research focused on the factors affecting the study of China, the study of Henan Province and similar regions to develop a more scientific and effective promotional strategies provide a certain theoretical basis.

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