Research on BIM technology diffusion barrier - based on innovation diffusion theory

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Abstract. Through the research on the current situation of the popularization and application of BIM technology in China, it is found that its penetration rate is still very low compared with developed countries. With the five main factors affecting the speed of dissemination of new technologies, and based on China's social structure, economic development level and social and cultural trends, the important factor of the use cost is introduced, so as to analyze the obstacles of BIM diffusion in China. Finally, some feasible suggestions are made for these obstacles.

1. Introduction

Technology around the world is changing at an unprecedented rate, and the contribution of new technologies to economic growth can be realized if they are widely applied and used. The application of Building Information Modeling (BIM) began in the United States. The General Services Administration (GSA) launched the national 3d-4d-BIM program in 2003 and published a series of BIM technical guidelines.

N Gu¹ found that there were many factors influencing the application of BIM in enterprises, which can be divided into two main types: functional requirements and requirements of technical tools, and non-technical strategic issues. M Hamma-Adama² conducted a questionnaire survey of the construction industry in Nigeria, and made data analysis. It was concluded that there were few enterprises adopting BIM technology, and the promotion of BIM was only the initial stage. B Gledson³ utilized the online questionnaire research method to quantitatively investigate the current situation of 4D BIM innovation diffusion in the UK construction industry, and found that its adoption rate is on the rise. C Merschbrock⁴ through the health care of large construction projects, the study found the change agent, cloud computing infrastructure, new roles and responsibilities, BIM contract, IS the learning environment and software developer participation factors are significant factors of BIM which spread successfully in the project. Other construction project design instance basis was provided for the implementation of BIM. Z Zahrizan⁵ has conducted an exploratory study through the literature review and the organization of Malaysia's BIM experience. The results demonstrated that it was difficult for Malaysian construction enterprises to implement BIM because there was no national BIM standard.

Through the DEMATEL method, Xu Youquan⁶ obtained the order of importance of various factors affecting the promotion of BIM technology and the causal relationship between them, and proposed feasible suggestions for the promotion and application of BIM. Tang Xiaoling⁷ used the Bass model to technology diffusion to estimate the innovation coefficient and imitation coefficient in the process of BIM technology diffusion, and made relevant predictions on the trend of China's construction
enterprises using BIM technology in the future. He Qinghua\cite{8} combined with engineering project examples and BIM software interoperability analysis, and found the problems and obstacles in the application of BIM technology in China. Hao Li\cite{9} started with various typical project cases of BIM technology application in China, and analyzed the problems existing in the application of BIM technology, so as to propose specific measures to promote the application of BIM technology in a targeted manner. Zheng Huahai\cite{10} reviewed the current research and application status of BIM technology from BIM basic theory. Data exchange standard IFC extension research, BIM software development and BIM technology in engineering applications at home and abroad. In case study, Hua Y Y\cite{11} found that innovation culture has a great influence on BIM diffusion, and its communication dimension is the most prominent one.

Although scholars at home and abroad have been fully studied the spread of BIM technology and the obstacles encountered, few scholars have conducted detailed research on the diffusion barrier of BIM technology based on the theory of innovation diffusion.

2. An overview of innovation diffusion theory

In the 1960s, the famous American scholar Everett Rogers proposed the traditional theory of propagation and diffusion effects, known as the "innovation diffusion theory". The theory holds that innovation is a basic social process, and people can be persuaded by the media to gradually accept innovative ideas, new things and new products. Rogers believes that innovation can be a novel idea, a new social practice or something new; innovation spreads through social networks. He also believes that the spread of communication is of great importance and is an indispensable factor in the period of social change.

Rogers\cite{12} proposed the characteristics of the proliferation of new technologies, and there are mainly five factors that affect the speed of its dissemination. Namely: 1) Relative advantage. It refers to the degree of advantage consumers feel when using innovation. It usually manifests as economic gains, increases efficiency or other benefits; 2) Compatibility. It refers to the extent to which the use of innovation is consistent with the existing values, past experience and needs of potential adopters; 3) Complexity. It refers to the extent to which consumers find it relatively difficult to understand and use innovation; 4) Observability. It refers to the extent to which the results of innovation can be observed and communicated to others; 5) Trialability. It refers to the extent to which innovation can be implemented and tested on a small scale before being used.

This theory has been widely used in Western countries and has successfully explained and predicted the spread of many new technologies.

3. Building Information Modeling

Building Information Modeling was founded in 1975 by Professor Chuck Eastman of Georgia Tech University. Up to now, BIM technology has experienced a budding phase, a production phase and a development phase. The American National BIM standard defines it as: "BIM is a digital representation of the physical and functional properties of the facility; BIM is a shared knowledge resource, a process to share information about this facility, and to provide a reliable basis for all decisions in the whole life cycle of the facility from concept to dismantling. At different stages of the project, diverse stakeholders can support and reflect the collaborative work of their respective functions by inserting, extracting, updating and modifying information in BIM". BIM is compared with traditional computer aided design (CAD) technology. It can restore the geometric and rich semantic information of the building model and the relationship between them, so as to support the sharing of life cycle data\cite{13}.

4. The promotion of BIM in China

According to the data released by China's BIM portal, it can be seen that the scale of China's building information model market has increased from 2011 to 2017 (as shown in Figure 2). After the logistic model was used for fitting, the value of R² was 0.917, indicating that the fitting effect was fine.
Therefore, the diffusion of BIM in China conforms to the S-type growth curve (as shown in Figure 3). It can also be seen from Figure 3 that China's BIM diffusion is in the initial stage and transitions to the acceleration stage. Although BIM technology has been popularized for more than a decade, there are still situations in which promotion is insufficient and implementation is difficult.

4.1 Status of BIM policy promotion
China's "2011-2015 Construction Industry Informatization Development Outline" issued by China in May 2011 clearly proposes the technical application of accelerating the development of Building Information Model (BIM) [14]. In June 2015, the Ministry of Housing and Urban-Rural Development issued the "Guiding Opinions on Promoting the Application of Building Information Models", which set clear BIM targets for Grade A survey and design units in the construction industry and special-level
and first-class housing construction enterprises[15]. In August 2016, China issued the "2016-2020 Construction Industry Informatization Development Outline", which put forward more specific and detailed requirements for BIM applications in engineering construction and supervision, information technology application, and standardization construction[16].

4.2 The promotion status of BIM in construction industry
In 2010 and 2011, the Commercial Real Estate Professional Committee of the China Real Estate Association issued the "China Commercial Real Estate BIM Application Research Report 2010" and the "China Engineering Construction BIM Application Research Report 2011". These reports indicate that the current BIM application is in the initial stage[17]. In 2011, Zhang Lei[18] found through questionnaires survey that 21.87% of people are familiar with BIM, and more than 78.13% of them know less about BIM. "China's Construction Industry Informatization Development Report (2014) - BIM application and development" in 2014 reflects the application situation of China's BIM in the same year. The investigation shows that the application of BIM in 2014 has been transferred from the design stage to the construction stage, but the application depth and level are far from enough. The application of BIM in the construction stage is still in the exploratory stage, and there are few cases of BIM application. At this time, the value of BIM is fully affirmed by the vast construction enterprises, but at the same time, most enterprises are watching and fail to invest sufficient funds to promote the application of BIM[19].

In 2017, Xu Shijie[20] discovered through the investigation of a construction project that the application of BIM technology is still just beginning in China, and there are still many difficulties and obstacles in the process of research promotion.

5. Influencing factors of BIM technology innovation diffusion
According to the theory of innovation diffusion, BIM technology diffusion refers to the transfer and exchange of BIM technology among members of the construction industry system through various channels[21], and enables construction practitioners to accept this new technology. In the investigation of the spread and popularization of some high and new technology in China, Jiao Shuo[22] found that a decisive factor in determining the speed of the spread of certain high-tech in China is the cost of use. That is, the economic resources that people must pay to use a certain technology. However, Rogers proposed that the theory of innovation diffusion is under developed economic conditions, so there is no detailed explanation of the economic use cost. Therefore, this article has added the cost of use under the five main factors that Rogers proposed influencing the spread of new technologies. Although the penetration rate of BIM technology in China has been relatively low so far, after more than ten years of promotion and application, its relative advantage, observability and trialability have been well interpreted. Therefore, this paper will illustrate the diffusion barrier of BIM technology in China with three aspects of its compatibility, complexity and cost of application, and introduce the important factor of time use cost in terms of the cost of use.

5.1 Compatibility
In some areas, the professional knowledge of BIM is still in an immature stage, and they are unwilling to change their inherent thinking patterns and working methods, because they believe that it takes a lot of energy and time to make changes. In the early days of the introduction of BIM technology, relevant practitioners are required to study or train. Some scholars have proved that learning new technology requires a certain cost for any learner, and under the influence of learning cost, learners usually continue to learn their technical knowledge and accumulate more technical fields. Different learners learn what technology has path dependence, which means that the structure and level of the original technological knowledge largely determine what technology they will learn in the future[23]. As a result, the existing values of potential adopters, past experience, and the need to learn to use BIM technology run counter to each other.
5.2 Complexity
The key to BIM technology is to achieve interoperability and visualization through continuous and accurate information communication throughout the life cycle. Organization and human-centered issues are the biggest challenges for BIM technology applications[24]. The life cycle of the project has the characteristics of phased, multi-participating, interdisciplinary, etc. Since the current technology is not mature enough, the information interoperability of the built environment cannot be well solved. Multiple data transfer and delivery methods and rules coexist, making BIM applications more complex during the life cycle of project construction[25]. Roshana Takim[26] believes that BIM technology is a very powerful tool that allows users to create a visual simulation of a project and provide a virtual prototype of the building before construction. However, due to the complexity of the process, BIM requires specialized training. BIM technology involves more software, such as Revit, Navisworks, Fuzor, Civil3D, Tekla, etc. The complexity of technical learning can be seen, so this has brought certain difficulties to those who learn BIM technology. The information exchange and sharing of the project, as well as the discussion of technical problems, are also of great significance, which require the full communication and cooperation between the team and personnel of the department, especially the team cooperation. Only through sufficient communication and cooperation can we effectively share information and effectively solve the problems we face. Patrick Lencioni[27] believes that there are five skill barriers to effective teamwork, namely lack of trust, fear (in communication), lack of (physical and mental) input, evasion of responsibility, and disregard of results (focus on individual performance, ignore collective effects). Therefore, this makes the application of BIM technology more complex throughout the life cycle of the project.

5.3 Cost of use

5.3.1 Economic cost. The application of BIM technology in enterprises mainly includes the following two aspects: the financial revenue and expenditure of the enterprise and the additional cost of the enterprise. The financial expenditure and income of a company are related to the future development of the enterprise. Without the economic foundation, the construction of the superstructure cannot be carried out. Enterprises may invest a lot of capital costs in the early stage of BIM technology application, so the financial situation of enterprises must be considered[28]. In addition, companies using BIM technology also require additional costs, including infrastructure investment, hardware upgrade costs, software costs, and personnel training costs.

5.3.2 Time cost. Enterprises will invest a lot of time cost in the early stage of BIM application, and spend one unit time on technical learning activities. The company will reduce one unit of time for normal production and operation activities, thus losing some opportunities to create wealth. As a result of the decision of whether or not to carry out technical learning activities, the time value of technical learning has become an important consideration. Liu Hongwei[29] believes that enterprises are composed of individual individuals, and the technical learning of enterprises must be completed by people. It takes a certain amount of time for any learner to learn any new technical knowledge. Taking time out of normal work to learn, the loss caused by stopping work constitutes the cost of labor opportunities.

6. Outlook
Many scholars have proposed solutions to the problems existing in the above BIM promotion. For example, the literature[20] put forward rationalization proposals from the government level, industry authorities, and enterprise level. Here are a few more rough additions. First, when the government introduces new laws and administrative regulations, it should first improve the relevant local laws and regulations and the standard specifications of BIM technology according to the BIM experience of countries around the world. Second, local governments should formulate and improve subsidy policies in a timely manner, and formulate different levels of subsidy standards according to the status of the
project to stimulate various construction, engineering and construction enterprises to actively promote the application of BIM technology. Third, enterprises should set up relevant departments for BIM technology application under the support of policies and introduce relevant personnel of BIM technology. It is also necessary to increase promotion of BIM technology in grassroots teams, strengthen training, set up talent training incentive policies, and accelerate the informationization process of enterprises.

7. Conclusion
Building Information Modeling (BIM) is widely recognized as a new tool to increase productivity, efficiency and collaboration in the construction industry. The total output value of China's construction industry is very huge. Although the growth has slowed in recent years, the high total output value and the very low information rate make the construction information still have a great increase in the space. Some scholars have proved that the penetration rate of BIM is very fast in recent years, and the trend of development is swift and violent. This paper analyzes the obstacles encountered in the promotion and application of BIM technology in China based on innovation diffusion theory. Of course, there are still many shortcomings. All parties should actively face these obstacles, so that BIM can be effectively popularized and then applied, and plays a significant role in the development of China's construction and engineering industries.

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