

Key Factors Affecting BIM Adoption in China Based on TOE&RC

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Abstract. In recent years, research on BIM standards, practical application and barriers have been made certain progress by researchers and practitioners, but research on the key factors that affecting whether companies to adopt BIM or not are rare. Within the TOE&RC framework which is based on TOE framework, the key factors-Technology, Organization, Environment, Risk and Cost-that affecting enterprise adoption of BIM are illustrate. The conclusion provides reference and guidance for the BIM-upcoming companies, and the future research direction is also presented.

Introduction

Building Information Modeling (BIM) has been accepted as a new revolutionary theory and technology in the AEC (Architecture, Engineering and Construction) industry [1]. It can be defined as a method to improve the project productivity and quality by generating and managing a digital model of a building through the lifecycle [2]. The successful use/adoption of BIM could be beneficial for all the project participants, the agreeable benefits of BIM could be summarized as reduced rework and shorten project duration [3], cut down project cost [4] et al.

However, the advantage gained from BIM has not been completely emerged in the process of its applying in the AEC industry. Only 3% of companies suppose they gained the complete benefits of BIM according to a report from Mc-Graw Construction [5]. Such a divergence between anticipant income and actual benefits of BIM could explain the limited adoption of BIM by AEC Company at a certain extent. Coming with researchers and practitioners' accelerate interests in BIM, what makes BIM implementing widely in AEC industry has become focus of investigators. In previous literatures, various reasons causing specific person like architects to be limited/not use of BIM have been presented [6, 7]. But researches on factors that affecting the adoption of BIM at firm level are rare.

The purpose of this paper is to theoretically inspect the factors affecting the adoption of BIM at form level. This research try to study the following issues: what factors affecting the companies' adoption behaviors of BIM and how does it work. And this research plan to use the TOE&RC model to research the factors that influence the BIM adopt at firm level.

Research Background

BIM Applying in China. BIM has become the focus of researchers and practitioners in China, and it has also been considered as the revolutionary technology to conquer the issues exist in China AEC industry, which are Information Island, organization gap, resource wasted and cost overrun. According to a survey by Mc-Graw Hill [8], there are almost 70% of company have used BIM in their

works. And Software vendor and universities are the major pusher for BIM. However, the majority of the AEC industry firms in China seem lack of confidence in BIM. The report by Mc-Graw Hill Construction presents that only 13% of firms have used BIM on their projects.

TOE. Technology-Organization-Environment model (TOE) is put forward on the basis of Technology Acceptance Model (TAE) and Diffusion of Innovation (DOI) by Tornatzky et al [9], they provided that TOE are the main elements that affecting firms' adoption of a new technology [10]. The TOE has been provided a reasonable view for understanding technology adopt analysis. However, the TOE model must be reasonable expanded for understanding the firms' BIM adoption behavior in Chinese ACE industry. There are three kinds of reason as follows: a) cost and ROI (return of investment) are the firms' most care about, while the BIM software are always expensive and the ROI is uncertain; b) risk preference of project leader/firm are dramatically different. Thus, the TOE&RC model is put forward for BIM adopt analysis based on TOE. See Fig. 1.

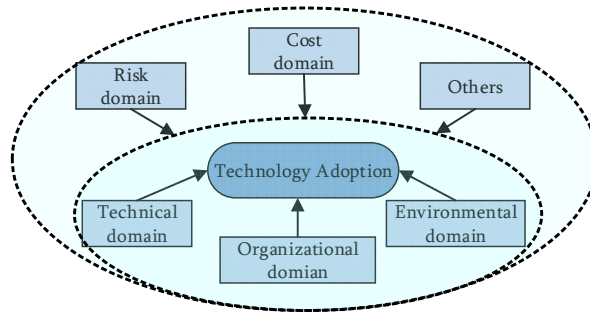


Fig. 1 TOE&RC framework.

Variables of the TOE&RC

According to the TOE&RC, a Fishbone diagrams is put forward to illustrate the main elements that affecting firms' BIM adopt, see Fig. 2.

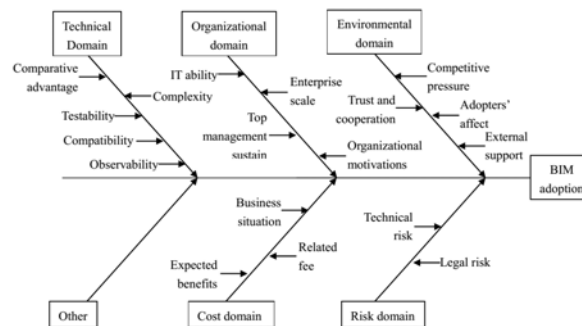


Fig. 2 Fishbone diagram based TOE&RC.

Technical Domain. In the TOE framework, technical feature is the primary factor that affecting enterprises' adoption of innovative technology [10]. And there are main five general feature of innovative technology as follows [11]: Comparative advantage, Complexity, Compatibility, Testability and Observability.

Comparative Advantage. In the area of economics, comparative advantage refers to the ability of a company to produce a particular good or service at a lower opportunity cost than another company. In AEC industry, BIM is performed much better at visualization, schedule simulation, clash detection and information extraction than traditional CAD technology.

Complexity. Whyte [12] points out that the complexity of technology is a barrier for technology

adoption. To date, there are almost 100 kinds software support BIM technology in China, how to choose the best suitable software from software company is such a big problem for the BIM preparing firm that they have to spend months to ask professional software consult institute for help.

Compatibility. Compatibility refers to the consistence between the innovative technology and the organizations' existing experiences [11], if the innovative technology is consistency with the exiting technology/work flow/work practices, the possibility of technology adoption will be increased [11]. However, according to related literatures in china, technology compatibility is one of the considerations of the BIM adopting company while work practice and work flow is out of the consideration.

Testability. Testability refers to the experimental practice of new technology in a limited range. BIM has a big advantage of testability since firms even an individual person can practice most function of BIM such as 3D visualization, clash detection and cost estimation et al. As learned from so many companies, most enterprise in china chooses to apply BIM in a limited range of project before enterprise level BIM adoption.

Observability. Observability refers to the results of new technology can be more obviously to be observed or measured. As it is commonly accepted BIM holds significant advantages at 3D visualization and clash detection. The effortless observability of BIM to organization top management is a contributing factor for BIM adoption.

Organizational Domain.

About 70000 firms (qualified general contracting and professional constructing construction enterprises) exist in china AEC industry [13]. Further, most of them are large scale groups. Therefore, organizational domain is also necessary to be considered as one of the affecting factors of BIM adoption behavior.

Enterprise Scale. Enterprise scale is one of the main factors affecting enterprise technology adoption decision, known as a comprehensive reflection of many elements of organization [14, 15]. Taking the advantages in risk resist and economies of scale into consideration, enterprise with large scale easier to adopt innovative technology in the early stages of the promotion of innovative technology applications [11, 16].

IT Ability. Technology adoption activity is constrained by the situation in which IT conditions are poor [17]. Previous studies have indicated that lacking of information technology application experience and limited interest in learning some IT technology such as BIM are the two main features for most AEC companies [18, 19]. Providing moderate training, practice and certain professor to deal with various issues during the period of innovate technology utilization resulting in increased managers' perceptions of technology easier use [20-22].

Top Management Sustain. It has been statement that top management sustain will multiply persons' approval of information technology usefulness [23-25]. BIM application needs sufficient resources and the right environment which only could be acquired from top management support, thus making it easier to accept BIM [26].

Organizational Motivations. Organizational motivations are the fundamental factor that affecting BIM adoption in AEC industry firms and the motivations could be divided into two categories: Intrinsic motivation and extrinsic motivation. Intrinsic motivations refers to some enterprise internal factors prompt firm to active use BIM, while extrinsic motivation refers to firms are influenced by external factors and is forced to adopt BIM. To date, extrinsic motivation is considered to be the main factor that encourages enterprise to adopt BIM in china.

Environmental Domain

Competitive Pressure. Competitive pressure refers to the degree of pressure feels from industry [27]. Enterprise needs to take more effective technology to improve its core competitiveness as the greater competition. Whyte point out that widely degree of technology use is the main factor that affecting the Virtual Reality technology adoption in British based on his investigation. According to government documents of Korea and USA et al, BIM is must applied to a certain scale of project invested by government. And as it illustrated that along with the considerably BIM adopted projects in 2008, the BIM adopted projects increased very fast in McGraw Smart market Report 2009.

External Support. Eastman [28] pointed out that external support during the process of BIM implementation is one of the important factor affecting enterprise BIM adoption, and the support are mainly stem from software suppliers, consulting company, scientific research institutions and government. And the support from government is the most important factor [29].

Trust and Cooperation. Previous studies have proved BIM application has obviously cross-organizational characteristics [26]. Trust and cooperation are the critical factors affecting BIM application across the organization.

Adopters' Affect. Under the circumstances of similarity advantage of competence, enterprise adopt BIM or not inevitably influenced by competitors upstream and downstream related enterprises in AEC industry, such as material suppliers and design institute. In the age of BIM promotion, most company is in the stage of waiting and wandering because of inaccurate effect of BIM using. With the increasing number of BIM adopt firm, more and more enterprise will easily adopt BIM.

Cost Domain

Business Situation. Enterprise business situation is another important factor the affecting BIM adopt. When business situation is good, companies are more inclined to keep their original production and reluctant to adopt new technology.

Related Fee. Based on survey about 30 enterprise of American construction industry association, Songer et al point out that high cost and endless investment of IT applications is a major obstacle for IT adoption. [30]. Admittedly, besides the abundant money spend on hardware and software, costs because of long-term training and practice are not low also. It can be seen that almost all the owners were not willing to spend their money on BIM software and hardware purchasing, even their time and effort on training and outsourcing their project to a third party.

Expected Benefits. Expected benefit of information technology is a positive factor for BIM adopt in cost domain [31]. The ultimate aim of enterprise is to obtain profits while BIM application needs to invest a lot of manpower and material resources and this situation will last for a long time, which will have a negative impact on the ROI. However, the economic benefits and quantitative metric of BIM is Non-existent. ROI is the most asked question by the conference participants.

Risk Domain

AEC industry in China is facing more intense market and policy environment in 2014. Market and policy risk are becoming an important potential impact factor of BIM adopt activity.

Technical Risk. Hundreds of BIM software is provided by different software companies with different characters. Visualization, coordination and plotting are the main function. Maintenance, security, interoperability and staff training of the software is neglected or even regardless, and these factors leading to a conservative attitude towards BIM adoption.

Legal Risk. BIM application may lead to information restricting and changes in the means of

information transmission, it would have a broad impact on traditional construction activities and social activities, and legal gaps are existing such as tax issues, legal validity of electronic documents, ownership of the model etc. [31].

Conclusions

BIM technology and their increasing application are bring some deep changes in AEC industry, while we still know limited about companies behavioral intentions to adopt BIM. In order to figure out and advance this issue, this study using TOE&RC framework investigated the factors affecting BIM adoption. This study is one of the first to take Risk and Cost into consideration of BIM adoption. What is more, this paper suggests that further studies should pay more attention on the following two aspects:

Relationship between factors. Five most important kinds of factors are summarized in this research, while the relationship between each factors are not discussed in this article. However, it is necessary to clarify the interaction relationship between factors, so certain attention must be paid on the relationship research by further researchers.

BIM application planning. Types of companies are existing in AEC industry such as design institute, Construction Company, owners, government and suppliers, and scale of each company in their own category is different, and the purpose of BIM adopt is not always same. It can be predicted that BIM implementation planning based on the characteristics of enterprises will be an important direction for future research.

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