Development of Building Information Modelling in China: A Review of Policy Trends

Yingnan Yang, Yidan Zhang* and Lin Yuan
Department of Civil Engineering, Zhejiang University, Hangzhou City, Zhejiang Province, 310058, China
*Corresponding author’s e-mail: 3130102512@zju.edu.cn

Abstract. Currently, compared with the technical support needed for adopting Building Information Modelling (BIM), the scholars didn’t pay sufficient efforts on sociology. This paper examines developments of BIM in the architecture, engineering, and construction (AEC) industry in China, with a particular focus on the policy support for government–industry linkages. The paper shows how different regions in China have responded to the policy initiatives, and suggests that there have been some movements towards regional diversity for the developments of BIM in China. However, questions remain as to the development and potential of truly regional governance structures for BIM and the role of universities.

1. Introduction
Traditionally, the AEC industry has been regarded as the most opaque and low-tech industry [1]. Due to its complexity, the development of information technology is slower than that in other industries [2]. BIM as the core approach to the construction industry informatization, has attracted widespread attention around the world [3], but the promotion of BIM is still a hard problem all over the world. Randy Deutsch et al. put forward that BIM is about 10% technology and 90% sociology. Ninety percent of what has been written, analyzed and studied about BIM so far is the technology. While the 10% technology and 90% sociology work itself out [4-5]. Early in 2009, Tsinghua University carried out a theoretical and empirical research on China BIM Standard (CBIMS) and completed BIM framework [6]. Over the years, it is supposed to study BIM institutional status to speed up the process of research and application of BIM in China.

The objectives of this study are as follows: (1) summarize BIM policies and standards from 2011 to 2018; (2) acquire a holistic research status for BIM from the perspective of institutional analysis; (3) identify emergent trends of the BIM institutional environment from studies in this field. The rest of this paper is structured as follows. Section 2 elaborates on the research methodology used in this study. Section 3 provides an in-depth analysis of the evolution and changes in the institutional arrangements by investigating the development trajectory of BIM in construction industry in China. Finally, section 4 concludes the findings and presents topics for further studies with regard to governance issues of BIM.

2. Research methodology
Data used in the study has been collected in a 360-degree approach, mainly from government official websites and various academic websites from 2011 to 2018, using “building information model” or “BIM policy” or “BIM standard” as keywords, and “civil” as the category, and obtained massive records abroad and at home. Based on the data, institutional analysis is adopted as a major analytical
method in this study. Five components of institutional analysis that Hollingsworth adopted are employed as a guideline for coding and identifying the institutional factors (see Table 1).

Table 1. Components of institutional analysis [7].

| 1  | Institutions: norms, rules, conventions, habits and values (see North, 1990; Brinton and Nee, 1998). |
| 2  | Institutional arrangements: markets, states, corporate hierarchies, networks, associations, communities (see Hollingsworth et al., 1994; Hollingsworth and Boyer, 1997). |
| 3  | Institutional sectors: financial system, system of education, business system, system of research (see Hollingsworth, 1997). |
| 4  | Organizations (see Powell and DiMaggio, 1991). |
| 5  | Outputs and performance: statutes; administrative decisions, the nature, quantity and quality of industrial products (see Hollingsworth, 1991, 1997; Dixit, 1996); sectoral and societal performance (see Hollingsworth and Streeck, 1994; Hollingsworth et al., 1990). |

3. Analysis and results

3.1. The development of BIM in foreign countries

Since the concept of BIM was put forward in 1975 in the United States and got prosperity, it is necessary to study the development of BIM in foreign countries, especially in the US. Therefore, we combed the process of foreign standards’ formation (see Table 2). The results show that the existing BIM standards are mainly from the government, universities and social groups. In addition to the US, many government agencies in Europe and Asia, like Finland, Norway, Denmark, Germany, Singapore, South Korea, etc., also have issued relevant specifications and guidelines for BIM [8-12].

Table 2. Foreign policies and regulations with specific regard to BIM promulgated.

| CTRY | Standards | CTRY | Standards | CTRY | Standards |
|------|-----------|------|-----------|------|-----------|
| US   | Contractor's Guide to BIM 1st/2nd Ed | US   | MIT CAD and BIM Guidelines | JP   | JIA BIM Guideline |
| US   | NBIMS V1/V2/V3 | US   | BIM Guidelines 1.6 | JP   | JBIM Guidelines* |
| US   | BIM Guidelines and Standards | US   | DDC BIM Standard Manual | AU   | NATSPEC National BIM Guide |
| US   | Minimum BIM Requirement | US   | National BIM Guide for Owners (NBGO) | AU   | National Guidelines for Digital Modeling |
| US   | BIM Standards for Arch.Eng.&Contr. | US   | BIM Planning Guide for Facility Owners | AU /NZL | ANZRS v.3 |
| US   | Ohio BIM protocol | US   | BIM Protocol Exhibit IU | ES   | FIDE (Spanish) |
| US   | The VA BIM Guide | US   | GSFC BIM Guide | NO   | Statsbygg-BIM Manual |
| US   | DB BIM Standards | US   | BIM Requirements | NO   | BIM Manual |
| US   | BIM Guide Series | DK   | NAEC | SG   | Singapore BIM Guide V1.0 |
| US   | EAD BIM Standard Manual | DK   | ICT Demands (Danish)-English Intro | CA   | AEC(CAN) BIM Protocol 1.0 |
| US   | BIM Guidelines and Standards | DE   | User Handbook Data Exchange BIM/IFC | GB   | AEC(UK) BIM Protocol v2.0 |
| US   | CoSA BIM Standards | NL   | Rdg BIM Norm (Dutch) | GB   | PAS1192-2:2013 |
| US   | DBB BIM Standards | FI   | BIM Requirements 2007 | GB   | The BIM Protocol |
| US   | DoD MHS Minimum BIM Requirements | FI   | Common BIM Requirements | KR   | BIM Application Guide in Construction Areas* |
| US   | GT BIM Requirements for Arch.Eng.&Contr. | HK   | HKIBIM Specification-Rev.3.0 | KR   | 3D Architectural BIM Design* |
| US   | BIM Project Execution Planning Guide | HK   | BIM User Guide for Development and Construction | KR   | Guidebook for BIM Application in Facilities Industry* |

Note: Data is collected mainly from websites and some academic papers. CTRY stands for country. The names of countries are represented by abbreviations.
3.2. The development of BIM in China
Compared with the technical research on BIM, the study about social factors in the process of BIM promotion is relatively lacking [13]. Since 2011, the state has promulgated “2011-2015 construction industry informatization development outline”, “Guidance on the application of building information model” and other important documents. This study collected BIM-related policies and standards at national and provincial levels from May 2011 to January 2018 (see figure 1).

Note: The shadow part indicates that relevant standards were put forward in this region.

MOHURD: The Ministry of Housing and Urban-Rural Development

Figure 1. The time-history graph for the promulgation of construction informatization policies.

3.3. Institutional analysis of BIM in China
Since BIM is a set of social technology system, this section discusses its development combining the certain institutional environment and social system. Firstly, to establish the China's general institutional framework, this study briefly described its supporting environments and the activities undertaken by all participants that involved in the construction of institutional environment. Secondly, this study focused on the dynamic evolution of BIM and summarized the characteristics of BIM development in different regions.

3.3.1. The construction of the institutions
According to the table 1, there are many factors worth noting in the existing construction industry, such as the informal system (the industry background), formal system (the legal system and the administrative environment). As for the background, excessive competition hinders the innovation of technology and systems [14]. In addition, since the problems like design changes caused by information gap are tolerated by the industry, the effectiveness of BIM is not sufficiently recognized by the market, resulting in the lack of motivation for enterprises to change. However, the industry background belongs to social embeddedness level, which changes very slow.

The formal systems of the institutional framework mainly include the legal system and the administrative environment. Laws and contract systems of AEC industry in China are lagging or even missing, leading to the confusion in the delimitation of legal responsibilities. The lack of these documents gradually extinguishes the enthusiasm of enterprises and industries. Therefore, the government should play their roles in the promotion and application of BIM technology. For example, the government should formulate laws to regulate the conduct of all parties and to specify the property rights of the BIM models and data [15]. As for the administrative environment, BIM promotion is mainly in the charge of the MOHURD and its subordinate departments, and it is deeply influenced by government's policies. Nowadays, building informatization has been referred to strategic heights [16].
In addition, the association of survey and design and other social organizations actively contribute to the BIM promotion, by enacting industry standards, conducting competitions and so on.

Based on the above, figure 2 was drawn to describe the tasks undertaken by the participating parties involved in the construction of BIM institutional environment. From the formulation of government policies, the establishment of standard system to the organization of seminars and related competitions, the government, industry associations, universities and research institutes work together and provide advices on the standardization and localization of BIM.

| Participating Parties                          | Project Activities                                                                 |
|-----------------------------------------------|------------------------------------------------------------------------------------|
| MOHURD                                        | Formulate policies                                                                 |
| Provincial Department of HURD                 | - Formulate Development Outline                                                   |
| City Department of HURD                       | - Implement the opinion of MOHURD on provincial development plans                 |
| Ministry of Science and Technology            | - Implement the opinion of MOHURD and provincial department of HURD               |
| China Academy of Building Research / China Institute of Building Standard Design & Research | - Select key projects of national science and technology support program            |
| China BIM Union                               | - Formulation of national standards                                              |
| Enterprises, universities, design institutes   | - Approval of project                                                             |
| General Administration of Quality Supervision | - Compiling with relevant units                                                   |
| Inspection and Quarantine                     | - Assist in preparation                                                           |
| China Association for Engineering Construction Standardization (CECS) | - Joint release                                                                   |
| China Engineering & Consulting Association    | - Formulation of association standards and industry guidelines                   |
|                                              | - Contests, seminars, exchanges                                                   |
|                                              | 2011-2015 construction industry informatization development outline              |
|                                              | 2016-2020 construction industry informatization development outline              |
|                                              | Guidance on the application of building information model                          |
|                                              | Unified standard for building information model                                    |
|                                              | Storage Standard of Building Design-Information Modeling                           |
|                                              | Deliver Standard of Building Design-Information Modeling                           |
|                                              | Standard for classification and coding of building constructions design information model |
|                                              | Standard for application of information model of manufacturing engineering       |
|                                              | Delivery standard for information model of urban rail transit                      |
|                                              | Application standard for information model of Urban Viaduct                       |
|                                              | Application standard for information model of Utility-tunnel Operations            |
|                                              | "Innovation cup" BIM application design competition                               |

Figure 2. The construction of the institutional environment.

3.3.2. The evolution of institutions with special regard to BIM

According to figure 1, the real point of entering the policy and standard setting phase is in 2014. Since then, around 20 relevant policies and standards are promulgated throughout the country every year. Numbers of provinces and municipalities, such as Beijing, Shanghai and Shenzhen, have promulgated the region’s BIM policy and standards with the staunch support of governments [17]. What’s more, the difference in development status of BIM institution environment between regions is obvious, as table 3 shows. The statues of BIM institutional environment in each region can be divided into three levels. The regions in Level 1 only have “Guidance on the application of building information model” issued by MOHURD in 2015, like Guizhou, Jilin, etc... These in Level 2 according to their own needs have issued specific BIM guidance for the region based on the MOHURD’s “Guidance”, lacking local standards compared with the Level 3.

Many scholars [16, 18-19] have pointed out that the development of BIM standard can promote the application of BIM in the whole process of project and BIM software development. However, we have to admit that BIM standard system in China is still in the developing stage, and still need a long time
to improve and perfect. In the process of establishing BIM standard, an exciting creation is that the unified standard for application of building engineering information model ("standard") fully combines the characteristics of China's national conditions and the current stage of construction industry, and puts forward a practical method: P-BIM (Professional task based BIM application), according to the project stage and professional division to refine and assign the tasks at each stage of the project to each major [20]. The introduction of "P-BIM" with its 21 sub-standards, assigns specific tasks to all professionals according to different stages of projects [21]. Meanwhile, one drawback is that the current P-BIM standards mainly concentrate on the stage of design and construction, and lack standards and norms in other stages.

Another noteworthy phenomenon is that the industry has discovered the application value of BIM in green buildings, sponge cities, assembly building and other fields. Just as far as assembly buildings are concerned, it is incomplete statistics that 83 related guidelines, atlas and standards were introduced from 2009 to 2018. The combinations of BIM and these hot spots, have produced a strong chemical reaction, leading to an urgent need for policies and standards to guide production and construction.3.

4. Discussions and conclusions
This paper followed by an intuitional analysis of BIM governance in the Chinese context, finds that the introduction of BIM proceeds in tandem with changes of the institutional arrangements, and the performance of BIM is closely related to its institutional environment, formal and informal. To fill the gaps of the current institutional arrangements for BIM, further efforts should be made as follow:

In the next decade, a sound standard system of BIM to cover the whole life cycle of construction should be set up, to clarify the responsibilities and rights of all parties involved and maximize the role of BIM in construction. The institutional environment at the national level has not yet formed, which calls for an acceleration in the formulation of BIM standard system and contract laws system. Therefore, the provinces and municipalities should be encouraged to introduce local guidance according to their own circumstances, as long as not conflicting with the national standards.

Although we performed an effective institutional analysis on the development of BIM, the data we obtained were not complete. Besides, more efforts should be made in case studies to support our ideas.

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