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CHALLENGES TO THE ADOPTION OF BIM IN THE CHINESE AEC INDUSTRIES

An Extended BIM Adoption Model

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Abstract. Despite strong encouragement by government guidelines and promoting efforts by the software industry, BIM is adopted at relatively slow speeds in construction industries across the world. The study presented in this paper examines the challenges to BIM adoption faced in particular in the Chinese construction industry across architecture, engineering and construction. We review recent literature addressing BIM adoption, develop a critique of common approaches to BIM adoption, and then propose our own, extended model to describe and assess BIM adoption processes. To demonstrate the model's suitability to evaluate temporal and collaborative dimensions during BIM adoption processes, we present results from a detailed survey we conducted among Chinese AEC professionals based on the extended model of BIM adoption and discuss how current Chinese BIM adoption in practice diverges from overseas BIM adoption strategies.

Keywords. BIM; Chinese construction practice; BIM workflow; cross-disciplinary collaboration; AEC.

1. Introduction

Building Information Management (BIM) is an umbrella term describing production and management processes in which construction procedures as well as physical and functional characteristics of buildings are represented digitally before they are committed to physical space and usage. BIM is typically employed to predict and control construction procedures and building performance with the aim of minimising cost in terms of energy, materials, and labour. Digital modelling provides several benefits to this end, including paperless editing and versioning, the possibility to provide current standard libraries of architectural elements and their attributes such as physical properties, cost and life spans, automated checking of conformity with some building codes and regulations, as well as networking and centralised data-bases allowing collaboration within and across companies and industries. BIM promises significant savings across various aspects of design, construction, maintenance, and removal/reuse, while its adoption also represents a significant challenge to industry in terms of necessary investment into both skills and technology. The tension between these promoting and inhibiting forces are particularly strong in the Chinese context, where development and construction activities continue to overshadow those of other countries, while much day to day work is conducted at low skill and basic technology levels. Besides software industries marketing BIM tools, the government has emerged as a major force promoting BIM adoption in China recently, with a guideline by the Ministry of housing and Urban-Rural Development aiming ambitiously for a national BIM adoption rate of 90% by the year 2020 (MOHURD 2015, p. 3). This figure is left open to interpretation, with regards to, for example, the threshold beyond which a project or a building might be considered BIM-based, the entirety to which this proportional measure refers, or how the remaining 10% are expected to break down be-tween incomplete BIM adoption and projects to which BIM may be deemed inapplicable.

2. Brief Literature Review

Besides the promotion of BIM benefits, barriers to BIM adoption and recommended recommendations have been published in related literature, such as GCCG (2011, pp. 5ff.). BIM adoption models such as the BIM Maturity Model, also known as “BIM Wedge” by Mark Bew and Mervyn Richards (2011, p. 16.) and the Point of Adoption Model (Succar & Kassem 2016, p. 7) have been proposed to assess and to promote BIM adoption. Authors in the field continue to report not only on BIM benefits, but also on persisting barriers to BIM adoption. Lindblad (2013) offers an extensive list of BIM benefits (i.e. factors in support of BIM adoption), including efficiency of handling project or building related information, streamlined construction processes, productivity increase, economic and environmental benefits including cost reductions, improved product quality, improved building sustainability, improved time management, more convenient data exchange, improved customer/client communications, faster analyses, less data input and transfer errors, enablement of collaborations, and improved building performance. Lindblad (2013) also offers an extensive list of barriers for BIM adoption including slow technology development, limited compatibility and interoperability, difficulties of capturing fragmented AEC industries in BIM, difficulties to apply BIM across the entire design process and building life cycle, limited libraries of standard objects, high demands on computing hardware, the emergence of new professional roles and relationships in the context of BIM, the lack of international standards, difficulties of using BIM models for unintended purposes, lack of interest in the part of professionals working with well-established non-BIM procedures, time and cost required for training, limited confidence in data security, as well as challenges of agreeing on model ownership, on project responsibilities, on access rights, on intellectual property rights, on contractual responsibilities for inaccuracies, and payment arrangements. Eadie et al. (2015) further list the enabling of e-procurement and pressure from government clients as drivers of BIM adoption, while they list as barriers the absence of fee structures for BIM-specific services, limited training literature, and the possible reluctance of specialists to engage with holistic planning approaches. Further barriers mentioned in existing literature are the necessary capital for investment into BIM adoption in particular for small practices, lack of case studies and samples, limited availability of BIM-ready collaborative partners, habits of 2D-based work, limited higher education BIM training, and a lack of BIM-ready samples for contractual documents (von Both 2012); the need for building proprietors to hire their own BIM teams to harness the benefits of BIM across the entire building life cycle and limited short-term benefits of BIM (He 2014); lack of mature policies and standards pertaining to BIM, uneven developments across different professions (Gu & London 2010), and a lack of BIM software adapted to local circumstances (MOHURD 2015). Several authors mention the limited availability of BIM specialists/managers as an obstacle to BIM adoption.

3. The Proposed Extended BIM Adoption Model

We note that current BIM adoption models do neither allow for the differentiated assessment of different building lifecycle stages, nor do they allow a differentiated quantitative assessment of the degree of adoption. The "BIM Wedge" by Bew and Richards (2011, p. 16.), for example, is in effect merely a one-dimensional four-point scale to measure quality rather than degree of adoption). Capturing these additional dimensions seems advisable for various reasons, most importantly the fact that degree of adoption and extent of adoption along building lifecycles (and hence across AEC professions) is necessary to assess consistency of BIM adoption, a key requirement to harness benefits of BIM adoption. To this end, we propose an extended model for the evaluation and visualisation of BIM adoption, which accommodates the "BIM Wedge" by Bew and Richards (GCCG 2011, p. 16) along one axis, building lifecycle stages along the second axis, and a dimension for quantification along the third axis (figure 1).

4. A Survey of BIM Adoption in Chinese Construction Practice

With a view to substantiating the extended BIM adoption model outlined above, we conducted an in-depth survey with BIM practitioners in China, drawn equally from architecture, engineering and construction (AEC) professions. The survey aimed to seek answers to the following core questions:

- Do overseas models of BIM adoption and use apply to contemporary Chinese A/E/C practice?
- How do Chinese companies adopt BIM in actual practice?
- Does BIM adoption lead to closer cross-disciplinary collaboration and integration?

As Chinese A/E/C firms are likely to be driven to officially report BIM adoption successes to comply with government guidelines, motivations of actual BIM adoption processes in China may differ not only from those publicly reported, but also from those assumed in overseas BIM adoption models. Local Chinese construction practice can differ substantially from overseas practice, which requires a more differentiated view on BIM adoption.

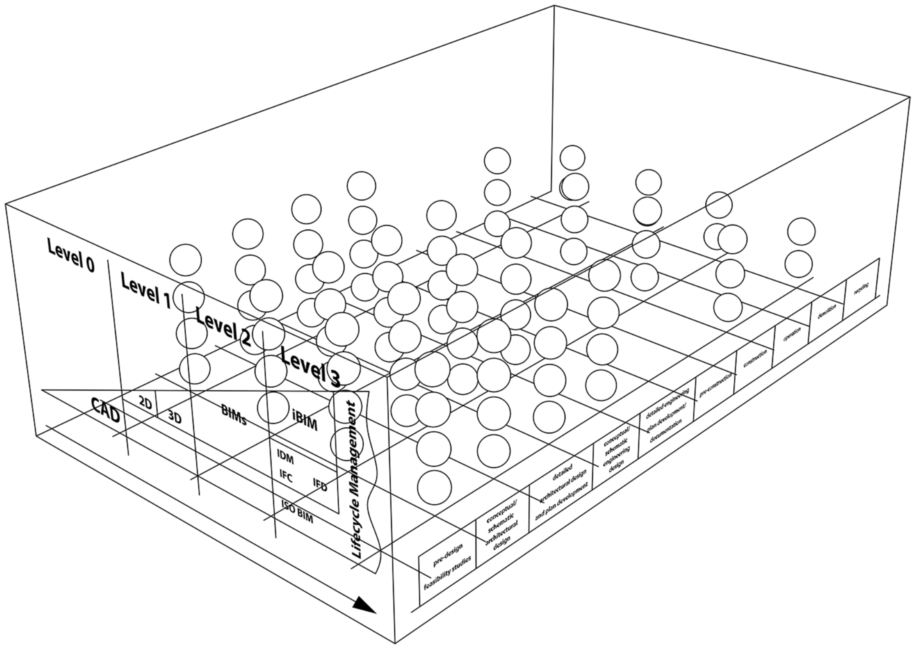

Figure 1. The proposed extended BIM adoption model accommodates the "BIM Wedge" by Bew and Richards (GCCG, 2011, p. 16) along one axis, building lifecycle stages along the second axis, and a dimension for quantification along the third axis.

Most Chinese design and construction processes are highly linearised, and professional separation is common. Most construction processes rely on 2D drawings to cope with demands for high-speed design and construction imposed by clients. While many firms report advanced BIM adoption rates, it is unclear whether BIM adoption is understood according to the widely accepted BIM adoption model developed by Bew and Richards for the GCCG (2011, p.16), or as requiring changes in existing professional relationships (Holzer 2016, p. 13).

For the study reported here, we focused on an in-depth survey of 13 AEC practitioners working in firms in the Shanghai / Suzhou region. Construction industry in this region is among the most technologically advanced in China and can be taken as representative of current advanced BIM adoption processes in the country. Survey participants were all drawn from companies that provide BIM services to their clients, with participants often occupying key roles in their firm's adoption of BIM. We found that all suitable participants worked in medium- to large-scale Local Design Institutes or construction firms. Smaller firms do not yet seem to adopt BIM technology or BIM-supported workflows. While the survey does not capture types of software used, it may be worth mentioning that the vast majority of BIM models currently constructed in the Chinese A/E/C professions use Revit as a common platform.

The study was planned and executed with the help of three undergraduate architecture students of XJTLU over the summer of 2016. The survey questions were developed based on the literature review and the theoretical model presented in the previous sections. The survey was provided in a bilingual English and Chinese version, but administered mostly in Chinese language. It comprised a catalogue of 146 questions, structured into main three parts: First, a set of questions examining BIM adoption during different stages of the design and construction process; second, a set of questions relating to observations of BIM adoption reported in overseas studies, answered on a Likert scale; and third, open-ended questions to be answered during a brief semi-structured interview.

5. Analysis of Survey Results

5.1. BIM ADOPTION DURING DIFFERENT STAGES OF THE DESIGN AND CONSTRUCTION PROCESS

Analysis of the collected survey data confirmed that, besides some advanced high profile projects, most Chinese design and construction processes are highly linearized and characterized by a separation of professions. Most surveyed AEC professionals describe their profession's typical workflow as predominantly linear, with limited temporal overlaps of architecture and engineering process stages. This is even the case for professionals working in large design institutes, where different professions work in close physical proximity to each other. Figure 2 illustrates BIM adoption of Chinese design and construction firms based on the self-assessment of surveyed A/E/C professionals in the typical stages of the Chinese design and construction pro-cess (x axis), in relation to levels of BIM maturity (y axis). Deeper shades of colour indicate similar answers from several survey participants. The levels of BIM adoption are defined as follows: 0 = computer drawings, communicated on paper; 1 = computer drawings and models, communicated digitally; 2 = computer drawings and models communicated digitally, enhanced for decision support; 3 = computer drawings and models enhanced for decision support, communicated digitally via a centralised data hub. The graph remains identical to the x axis if no BIM use is indicated.

Based on surveyed professionals' self-assessment, BIM is reported as widely adopted at a relatively high level throughout the design and construction process stages across the A/E/C industries in China. Different disciplines indicate varying levels of BIM adoption depending on their professional focus: Architecture and engineering professionals tend to adopt BIM earlier in the design and construction process, whereas construction professionals mainly adopt BIM for the construction drawing and construction phases. Overall, A/E/C professionals report a strong focus on BIM use in the construction drawing stage. Very few surveyed professionals indicate BIM use for the purpose of building maintenance. The survey data further shows that the vast majority of BIM services is provided in-house, with firms preferring to set up internal BIM departments rather than relying on external specialised BIM service providers.

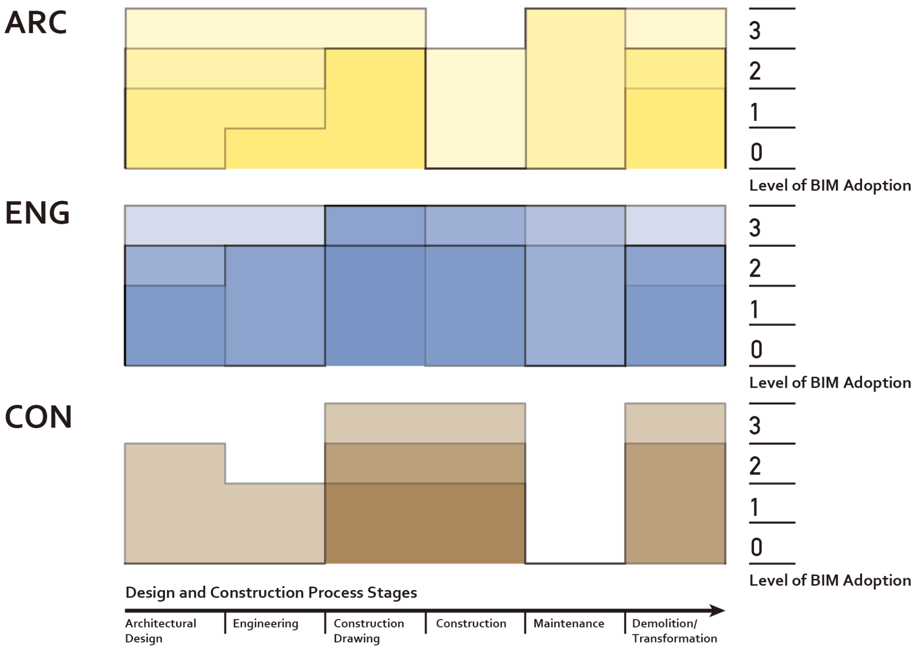

Figure 2. Self-reported BIM adoption during different stages of a design and construction process.

5.2. BIM ADOPTION IN CHINESE CONSTRUCTION PRACTICE COMPARED TO OVERSEAS STUDIES OF BIM ADOPTION

This section of the survey was based on questions answered on a seven point Likert scale. Survey participants tended to answer mostly within the central five-point range, avoiding the extremes of agreement and disagreement. Overall, results indicate a broad confirmation of overseas studies' results. Surveyed A/E/C professionals agreed that BIM adoption is strongly encour-aged through government guidelines and policies, while practical standards and guidelines are reported as not well developed. Legal implications of BIM and related contract documents are generally perceived as particularly unclear. Data collected in the open-ended interviews of the following survey section offered comparatively more and unexpected insights.

5.3. OPEN ENDED INTERVIEWS

The open-ended interviews provided a significant source of insight complementing and explaining results of the previous two sections of the survey. The two main questions asked in this section of the survey relate generally to factors motivating BIM adoption and factors discouraging BIM adoption. Survey participants typically offered additional opinions and observations relating to BIM in general. In this part of the survey, we noticed that most survey participants exclusively discussed their own discipline's needs and rarely mentioned coordination with other disciplines' requirements and workflows. Most surveyed professionals do not seem to see BIM adoption as related to increased cross-disciplinary collaboration and workflow integration across the A/E/C professions.

Survey participants' responses indicate that core motivations for BIM adoption in the Chinese A/E/C professions are government guidelines and client requirements. Both architecture and engineering professionals reported that BIM capacity helps their firms to secure contracts with overseas clients, whereas many Chinese clients currently perceive BIM as an unnecessary cost item. Chinese clients tend to merely ask for provision of a BIM model without requesting its use during the design and construction process.

Most benefits from BIM adoption were reported by construction professionals, in particular for projects involving prefabrication. Architecture and engineering professionals had a more mixed perception of BIM adoption. Several architecture professionals described BIM models as an extension of 3D visualisations of the finished building, to show to the client to demonstrate the firm's competence and added value to the project. Architects further commented that time and effort invested into the construction of BIM models does not result in benefits to the work of their discipline, whereas construction professionals commented that BIM models inherited from architects are of little use for the purposes of construction and have to be re-built. Overall, improved quality of the built environment was not reported as a concern and motivator of BIM adoption, as "most buildings in China are regular buildings" that can be designed and constructed quickly and efficiently based on precedents.

Both engineering and construction professionals commented that 3D BIM models require more precision and detail, and thus time, for data input com-pared to previous practice, where 2D drawings left much to the construction firms to decide on site. Answers to the open-ended questions further indicate that actual use of BIM is mostly limited to discipline-specific models, with each discipline constructing specific BIM models. Survey participants commented that BIM models constructed by other disciplines contain too much irrelevant data that produces large and difficult to handle files.

A reported core factor discouraging BIM adoption in the Chinese design and construction process is that official contract relevant documents are currently limited to 2D drawings. BIM models are often required by clients but are not (yet) contract relevant. As a result, BIM models are typically not used for the purpose of supporting the design and construction process, but usually built only after the 2D drawings for the official contract documentation are almost finished. BIM thus becomes an add-on to an established design process operating primarily on the basis of 2D CAD drawings. Survey participants described this process as (literally translated from Chinese) "post-BIM" or "after-the-fact-BIM", the creation of BIM models only after relevant decision making processes have already concluded.

Generally, workflows employing BIM are perceived by most professionals as slow and inefficient - with the exception of service engineering where clash detection is seen as a main benefit. Only one survey participant mentioned use of BIM during the actual design process, in the case of a large-scale high profile project with an international client. In that case BIM was used (among other reasons) to guarantee a high quality of construction and to prevent corruption on site by pre-defining each building in great detail.

6. Findings and Discussion: A New Perspective on BIM Adoption in China

While firms tend to officially present an official success story about BIM adoption and resulting opportunities in line with governmental guidelines, surveyed Chinese A/E/C professionals discussed both benefits and challenges of BIM adoption in their actual practice. We found that different participants of the same design process make varying assessments regarding the role and use of BIM in the same process. The survey indicates that BIM adoption in China focuses more on the presence of BIM models than on the workflows supported through such models. It is for example unclear how to interpret the Chinese government's call for 90% BIM adoption by 2020 - does this describe the mere presence of a BIM model or does it relate to a particular workflow? How can BIM adoption be measured?

With BIM still a novelty in the Chinese design and construction process (Zhang and Li 2013), work practices and processes have not yet been clarified or well established (Ding et al. 2014). While government guidelines push for widespread BIM adoption, many A/E/C professionals do not see a real need for or benefit in adopting BIM at this stage of development. Guidelines are seen as interfering with market-driven processes that emphasise speed and cost efficiency over integration and quality. To cope with these challenges, models of BIM adoption for the Chinese as well as overseas A/E/C industries do not yet seem to adequately consider factors relating to time and process. Chinese firms face excessively tight time constraints, which limit the scope of BIM adoption and the development of integrated and collaborative workflows.

Results of the study show that the presence of BIM models is not indicative of actual BIM adoption, as most surveyed companies produce BIM models only as add-ons to existing processes (described as "after-the-fact BIM" by several surveyed professionals). Similar to overseas studies, survey results indicate that new contract models are needed to truly establish BIM models as exchange platforms between different professions. This lack is a core challenge for Chinese companies aiming to adopt BIM.

7. Summary

In this paper we proposed an extended BIM adoption model, which allows for the differentiated assessment of BIM adoption during different building lifecycle stages, as well as the differentiated quantitative assessment of the degree of BIM adoption. We argue that capturing degree of adoption and extent of adoption along building lifecycles (and hence across AEC professions) is necessary to assess consistency of BIM adoption, which is a key requirement to harness benefits on BIM adoption. To substantiate the applicability of the extended BIM adoption model we presented an industry survey from China. Analysis of collected data confirmed that, besides some advanced high profile projects, most Chinese design and construction processes are highly linearized and characterized by a separation of professions, with each AEC profession constructing proprietary BIM models, typically only after the actual design process has already been completed. Chinese AEC professionals continue to rely on simplified 2D drawings to cope with high speed demands common in Chinese AEC practice. Despite most firms‘ official claim to advanced BIM adoption, only few AEC professionals reported actual benefits from their company’s adoption of BIM, and implied a limited scope of BIM adoption. Among those reporting benefits from BIM adoption are architecture and engineering firms working closely with overseas clients, construction firms employing BIM for enhancing management of construction processes, or firms utilizing BIM in relation to construction projects involving prefabrication - a practice that is still rare in China. Cross-disciplinary collaboration supported through BIM remains limited across the Chinese AEC industry. As the scope of this paper is limited, we will develop the project further in future, detailing the extended BIM adoption model as well as addressing specifically potential suggestions for Chinese AEC industries’ BIM adoption strategies as part of embracing more holistic workflows.

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