RE-EXAMINING CONTRACTOR'S BIM STRATEGIES: A CASE STUDY

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ABSTRACT

In the construction industry, building information modelling (BIM) is a promising technology to maintain a contractor's business competitive advantages. Although some BIM guides for contractors have been released by a set of countries or institutes, the BIM strategies as a part of contractors' business developmental strategies are rarely discussed. This paper aims to empirically investigate the BIM strategies for contractors from the institutional perspective. A case study of a German contractor is conducted. Data collected through interviews, site visit, and survey/questionnaire are analysed to identify the best practices in a leading contractor company in BIM lifecycle implementation. Suggestions are provided to better implement BIM in contractors' long-run business developmental strategies.

Keywords: *Building Information Modelling (BIM); BIM Strategies, Contractor.*

1. INTRODUCTION

Building Information Modelling (BIM) is gaining significant momentum in the development of construction project delivery methods for the past decade (Davies and Harty, 2011; Eastman *et al.*, 2011; Chen *et al.*, 2015). The adoption of BIM possesses enormous potential benefits and meanwhile brings challenges to various professionals in the construction industry. As both the information communication technology and process, BIM shall be appropriately implemented in the company business development strategies. Only by doing this, the potential benefits of BIM implementation could be fully achieved (NBIMS, 2007, 2012; Davies and Harty, 2011). Even though BIM guides or standards have been issued in many countries or regions (Zeiss, 2013; HKIBIM, 2009), and the contractor is increasingly aware of the importance of adopting BIM strategies to sharp their competitiveness in the global and domestic markets, the empirical evidence and best practices on the firm perspective are still scarce. Therefore, related studies would be valuable for the contractors to embrace the new trend of project delivery methods with the implementation of BIM.

This paper starts with the review of BIM concept and the development of BIM in the construction industry. It focuses on the critical factors for a contractor to successfully implement BIM. Particularly, the attention is drawn to regarding BIM implementation as a part of business development strategies for contractors. A case study of a Germany contractor is conducted to investigate the experience and lessons. From the case study, best practices are identified and suggestions on BIM strategies for contractors are made.

2. BIM AND ITS DEVELOPMENT

2.1. CONCEPT

The rise of BIM in the construction industry has been witnessed with an increasing popularity among vast groups of project managers, building professionals, IT vendors, government officers, and the like (RICS, 2013). According to Eastman *et al.* (2011), BIM was "a modelling technology and associated set of processes to produce, communicate and analyse building models". In the National BIM Standard, BIM was defined as "a digital representation of physical and functional characteristics of a facility" which

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serves as "a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle" (NBIMS, 2007a, 2012b). Davies and Harty (2011) referred BIM to a family of technologies and related practices used to manage the information for the purpose of delivering construction projects.

From the above three elaborations of the BIM concept, two important perspectives are highlighted. One is to regard BIM as information communication technologies (ICT), which enables the storage of building information, such as geometry, spatial relationships, quantities and properties of building components. The other one is to regard BIM as the technology-based processes, which include the 3D design presentation, integrated design and construction, centralized information management, and computer-aided subcontracting management. The basic idea is originated and developed from manufacturing industry. However, it is probably the unique features of the construction project and the traditional managerial processes that hinder the promotion of BIM in the construction industry.

2.2. ROADMAP

BIM has gained increasing popularity in the global construction markets. AIA (2006) reported about 60% of large size architecture firms use BIM in the USA. In Finnish, that figure is about 93% according to the Finnish ICT Barometer (2007). A Smart Market Report published by McGraw Hill Construction (2012) found out that 75% of the architecture, engineering, and construction (AEC) professionals in North America used BIM in their projects, and 62% of the surveyed BIM users used BIM on more than 30% of their projects. Furthermore, the promising future of BIM has been notified by many public building owners. Some of them (e.g. UK, USA, Denmark, Finland, Hong Kong, and Singapore) have already issued BIM guides or standards and started to demand the implementation of BIM in their projects. In addition, there has been an international census about the future of BIM in the construction industry. As shown in Table 1, many countries all over the world are building up their BIM roadmaps to utilize the potential benefits of BIM in their infrastructure and building projects.

Table 1: A Summary of BIM Roadmaps in Various Countries

China	12th 5-year plan (2011-2015)
UK	Compulsory after 2016
USA	Compulsory for Government funded Project after 2017
Singapore	Compulsory after 2015
HK	The Hong Kong Housing Authority requires BIM for all its new projects after 2014.
Norway	Encouraging instead of enforcing.
Denmark	Danish state clients such as the Palaces & Properties Agency, the Danish University Property Agency and the Defence Construction Service require BIM to be used for their projects.
Finland	The state property services agency, Senate Properties, require the use of BIM for its projects by 2007.
Germany	National BIM guide has been completed in 2014.
Netherlands	Since 2012 the Dutch Ministry of the Interior (RGD) requires BIM for large building maintenance projects.
South Korea	Compulsory for all large size projects and for all public sector projects by 2016.

Source: Adapted from Zeiss (2013) and HKIBIM (2009)

2.3. POTENTIALS AND CHALLENGES

Numerous studies have been conducted to disseminate the potentials of BIM technologies and related practices. The main potential benefits of BIM were summarized by NBIMS (2012) as follows: (1) Reduced cycle time (e.g. better communication, better management of delivery time); (2) Reduced

lifecycle cost (e.g. less waste, less re-work, and significantly reduced number of change orders); (3) Improved and sustainable product quality (e.g. off-site prefabrication with higher quality control, less possibility of accident occurrence, and more energy efficient); (4) 3D visualization and planning (e.g. allowing for analysis and simulation, vivid visualization for the client to detail the specifications); (5) Centralized information model (e.g. once established, BIM could be used for various stakeholders throughout the lifecycle); and (6) Fostering collaborative working relationships (e.g. improved communication and collaboration among project participants; higher Quality Project Execution and Decision-Making). Lu *et al.* (2013) summarized that the benefits of BIM implementation in the project delivery have been extensively discussed, such as improvements in engineering and design quality (Patrick and Raja, 2007), better time management (Azhar *et al.*, 2008; Patrick and Raja, 2007), increased labour productivity (Kaner *et al.*, 2008; Patrick and Raja, 2007; Sacks and Barak, 2008), and project cost saving (Sacks *et al.*, 2005). Additionally, these benefits had a number of empirical evidences. For example, CIFE (2007) reported 40% elimination of unbudgeted design changes, enhanced cost estimation accuracy within 3%, 80% reduction in time for cost estimation, and 7% project time saving. Lu *et al.* (2014) and Lu *et al.* (2015) stated that the implementation of BIM contributed about 6.92% cost saving. BIM is even said to be a significant development that it will bring a paradigm shift to the AEC industry.

The challenges of realizing the potential benefits of BIM implementation shall never be overlooked. Azhar (2011) summarized that the major risks of implementing BIM were technical risks (e.g. inter-operability among various information systems, and computability of digital data serving for the professional purposes), management issues (e.g. re-distribution of responsibilities and empowerment, collaborative culture and the operation capabilities of the project participants), legal contracting issues (e.g. ownership and patent rights), and economic issues (e.g. sharing of gains and pains, and payment methods), CIC (2013) pointed out the critical requirements for BIM implementation from the aspect of planning, adoption, technology, and performance, through examining the best practices in some leading countries. Smith (2014) reviewed the development of BIM practices in 10 countries, and identified the challenges of achieving BIM benefits should be handled in aspects of governmental and industrial driving power, national and global technical standard, legal contracts and procurement systems, BIM education and training, and business shift of construction companies. It should be pointed out that some of the challenges could not be dealt by one specific construction company, such as legal issues and the technical bottleneck, whilst some challenges can be overcome within the capacities of a company.

2.4. CONTRACTOR'S BIM STRATEGIES

The contractor is one of the key stakeholders in the delivery processes of the construction projects. Either attitudes of contractors towards BIM or the adopted BIM strategies could have great impacts on the project performance. There are already some reports or standards released especially for the contractors to implement BIM strategies in some countries and regions, like the USA (Ernstrom, 2006) and Singapore (BCA, 2013).More commonly, suggestions for contractors are included in the overall BIM guide or standards, which are made under some conditions and lacking of specificity. One of the assumptions in most of the BIM guides or standards is that every project party in a project open to BIM and dedicated to it. However, the maturity of BIM implementation in the different countries or regions is varying. Only a few countries have achieved relatively high level (see Table 1 as a reference). For most cases with the low level of BIM maturity, a contractor is expected to be more encouraged to take the proactive initiatives to master the BIM as technology and managerial processes.

According to Ernstrom (2006), Eastman *et al.*(2011), and BCA (2013), BIM practices of a contractor can be divided based on the three stages, namely, the tender stage, the pre-construction stage, and the construction stage. For each stage, the processes relating to the BIM implementation are identified: establishing BIM models and cost estimation at the tender stage; reviewing and developing models and model-based project planning/scheduling at the pre-construction stage; construction coordination, setting out and verification on site, prefabrication, and comparison between as-planned and as-built at the construction stage. For every identified process, specific BIM strategies could be employed to enhance the contractor's construction productivity.

However, the project-oriented BIM guides are not enough for a contractor to make significant business shift. As a company, a contractor needs to invest in new technologies, to re-organize its business structure, resources, and working processes, and to lead and train its employees to accept and master new technologies and working processes. To the best knowledge of the authors, the research on the BIM strategies for a contractor, from the perspective of business developmental strategies, is scarce.

3. METHODOLOGY

In this study, institutional analysis of both formal and informal institutions was applied to re-examine the contractors' BIM implementation as a part of their business developmental strategies. Institutional analysis in organisational studies focuses on characterizing the humanly devised rules in a company where humans interact according to certain "rules of the game" (North, 1990). Formal institutions are steady rules, which define the "normative system designed by management" or the "blueprint for behaviour". Whilst informal institutions define the actual behaviour of players (Scott, 1981). North (1990) and Jepperson (1991) argued that formal rules contain political rules, economic rules, and contractual arrangements, and informal rules include taboos, customs, routines, and traditions. Both formal and informal institutions help to give pattern to human behaviour by enabling and constraining their activities.

A case study was carried out in one of the top 10 contractors in Germany (the case company will be referred as the contractor from here on). The construction industry of German has been aware of the potential of BIM, and the contractor has initialled its business shift to BIM early in 2009. Till now, the contractor has harvested the benefits of BIM implementation at the tendering and bidding stage with significant time and cost saving and increased contract winning rate. Three pilot projects are being conducted to strengthen its business competitiveness by implementing BIM throughout the project lifecycle.

The qualitative and quantitative data were collected by mixed research methods, including interviews, field visit, archival records, and survey/questionnaire. Field visit and archival records were used to develop a brief understanding of the management system and strategies of the contractor company. A series of interviews were conducted to deepen the understanding, particularly in the BIM strategies. A survey was then conducted, and questionnaires were sent to the team members of an ongoing project through the company's online survey system. Based on the results of cast study, a framework model of BIM strategies for a contractor is established, and suggestions are made to embed BIM implementation as a part of the contractors' business development strategies.

4. BIM STRATEGIES FOR CONTRACTORS

The institutional settings, including both formal and informal institutions, are important for contractors to achieve BIM strategies in order to realize their business competitiveness. In the case study, some initiatives on formal institutions are identified, i.e. forming a business partnership, adoption of information and communications technology (ICT), setup of organisational structure, procurement arrangement and outsourcing management. Also, some initiatives on informal institutions are identified, which mainly refer to top-to-bottom leadership and encouragement towards new technologies and working processes, BIM education and training, and guidance for gradual BIM based working processes.

4.1. BIM DEVELOPMENT PARTNERSHIP (F1) AND ADOPTION OF ICT (F2)

The strategic shift towards BIM could never be separated from the investment in enterprise information systems and information communication technologies. The contractor is partnering with an IT company R, whose headquarters is located in Germany and business range covers most large-size international construction markets, such as the USA, European region, South Asia, and China. R is providing BIM-based IT solutions and follow-up services for the contractor. In return, the contractor shares building experiences and practical demands with R. A series of software to facilitate the implementation of BIM technologies and processes for owners, designers, and contractors in the construction industry have been introduced to the contractor. In particular, R is providing their software programs, and offering related

professional services. As reflected by the project managers and departmental heads of the contractor in the interviews, their partnership has technically helped the contractor in their business strategic shift.

The contractor is delivering dozens of projects in many regions of Germany. A BIM database is created in the headquarters of the contractor, which stores all the building models and related electrical documentary records. Authorization is straight and clearly identified so that the information maintenance and management can be secured.

4.2. ORGANISATIONAL STRUCTURE (F3)

Adjusting the organisational structure is one of the BIM strategies for the contractor. A BIM centre is separated from the former IT department. The centre is in charge of maintaining and managing the BIM database and providing BIM-related solutions or services for on-site project teams. For each project, at least one member of the centre will join the project team in order to bridge the on-site construction work with the virtual BIM and other enterprise information systems.

For the on-site project team of a specific construction project, a business manager and a project manager are in charge of the top commercial and managerial control. Under the project manager, there are usually deputy project manager, construction manager and a secretary assisting the management of on-site construction work, and the BIM coordinator(s) designated by the BIM centre. The responses from the interviews and survey show that both the construction management board and BIM coordinator(s) are important, and extensive interactions between the two groups are reported.

4.3. PROCUREMENT ARRANGEMENT (F4)

Procurement systems shall be prudentially chosen in order to fulfil the benefits of BIM. Procurement systems could be differing to varying extent in terms of financing approaches, distribution of responsibility of design and construction management, payment methods, and outsourcing arrangements (Hughes *et al.*, 2006). In the case study, the contractor is open to innovative procurement systems, especially to those with more flexibility in 3D modelling and integrating design and construction.

At the tender stage of one of the pilot projects, the client briefs the project concept and hires an architect to develop preliminary 2D drawings, and then invites contractors to bid for the building project. The contractor (for the case study) established a 3D model based on the 2D drawings and imported the 3D model into the professional software to make estimation of quantity take-off (QTO). Through the demonstration on strong advantages, such as 3D design accurate and quick QTO calculation, and efficient supply chain management, the contractor successfully persuades the client to employ BIM to accelerate the project delivery and achieve high building quality. Thus, the offer is awarded to the contractor, with a special agreement to implement BIM in the project delivery process. Due to the strict time limitation and new technologies of implementing BIM, a flexible and innovative turnkey contract is signed, and the contractor is responsible for development of the design and the construction of the physical building.

4.4. OUTSOURCING MANAGEMENT (F5)

The contractor has a good management of subcontractors and suppliers in a computer-aided approach. When the 3D model is ready, the contractor divides the work on the computer and sends Request for Quotation (RFQ) forms in the digital format to subcontractors and suppliers. Then, subcontractors and suppliers will firstly read the forms through the specific software, and input price information before sending back the appropriate RFQ forms to the contractor. Based on the assessment and summary of all RFQ data from subcontractors and suppliers, the contractor gives its biding offer to the client. After the contract was awarded, the contractor signed contracts with those whose RFQ information has been included in the final bidding offer.

4.5. TOP-TO-BOTTOM LEADERSHIP AND ENCOURAGEMENT (I1)

The BIM concept was introduced to the top management board of the contractor about 10 years ago. The R&D department of the contractor has conducted extensive research works before making the final

decision on adopting BIM strategies to enhance their business competitiveness in the long run. What is worthy to be mentioned is that the IT department forms a special task group, which becomes the BIM centre, to follow up technical issues in BIM implementation, and evaluate the cons and pros from the technical perspective. With the promotion and support from the top management board, the BIM education and training has been provided to all employees in the company.

4.6. BIM EDUCATION AND TRAINING (I2)

BIM education and training amongst the employees are essentially important. In order to well stem the high productivity of BIM implementation, the employees must have the necessary knowledge and capabilities in BIM. The effective education and training should cover two aspects. The first aspect is to gain technical capability that the employees have to understand and operate the BIM-related equipment and software programs. The second aspect to be adapted with the BIM-related processes. The contractor is periodically holding training seminars and experience sharing events to update the knowledge, and to foster the collaborative working habits among the employees. Based on gains and lessons learnt from the pilot projects, the contractor is able to re-evaluate and improve their processes. An internal management manual is created to provide guidance on standardized working processes with the involvement of BIM. The management manual introduces the details of how one specific BIM software program shall be appropriately used in the real practices. A service group at the headquarters of the contractor is responsible for refining the management manual and answering any enquiries about the BIM software programs. In extreme cases, they will contact the IT vendors to seek for solutions.

4.7. GRADUAL SCHEME FOR BIM BASED WORKING PROCESSES (I3)

Changes on the working processes are not easy to be quickly realized. The contractor has paid close attentions to the employees' attitudes towards BIM, and initialled a gradual scheme to make the process changes acceptable and inspiring. It starts with the 3D design and QTO calculation, and then spread to the planning and simulation. During the period of this case study, the process changes have happened at the construction stage, which refers to bridging BIM and actual buildings bi-directionally. The next step is to make the process changes happen at the operation and maintenance stage. The contractor uses internal online survey system to collect the employees' reflection and suggestions. According to some project managers and department heads of the contractor, it takes time to make all employees to be adapted to the changes, iterative interactions among different departments and different managerial levels are often needed.

What is more, the contractor is continuously providing some internship for university students. Those who have knowledge in BIM and can operate BIM software programs are in favour. After training, the selected students will be involved in ongoing construction projects as BIM coordinators. On one hand, the on-site workers will be more productive with the assistance of these BIM coordinators. On the other hand, those students can enhance their capabilities of BIM and get used to the new project delivery processes with BIM implementation.

5. DISCUSSIONS AND CONCLUSIONS

From the perspective of institutional analysis, some BIM strategies for a contractor company are identified. Those for formal institutions consist of:(F1) form partnership with IT vendor company to fulfil their own advantages; (F2) utilize the ICT technologies and refine the working processes; (F3) make change of organisational structure to match with the BIM related processes; (F4) adopt appropriate procurement systems in order to have flexible leadership in BIM implementation; and (F5) use the BIM functions to leverage the tendering and manage outsourcing relationships. Those for informal institutions include: (I1) top-to-bottom leadership and encouragement towards new technologies and working processes; (I2) BIM education and training to help employees gain necessary BIM knowledge and operation capabilities; and (I3) guidance for gradual scheme of BIM-based working processes.

As Zenger *et al.* (2002) argued that the two aspects of institutional settings must be carefully designed and their interplay can have significant impacts on the organisational performance. In the case study, the

five formal institutional initiatives are closely related to the three informal institutional initiatives. The investment on the BIM software programs and working processes (i.e. F1 and F2) will never be paid back without the employees' acceptance, understanding, and mastery, which is supported by top management board (i.e. I1), realized by education and training (i.e. I2). The gradual scheme of realizing the BIM-related changes (i.e. I3) is specially designed according to the developmental routine of BIM in the global construction industries and the current situation in the contractor as well. A contractor is suggested to work closely with IT companies (F1) since they have more experience in handling and developing the software. A BIM centre can be established to better support the implementation of BIM throughout the projects lifecycle. Education and training also play an important role because it is one of the methods to understand all efforts the contractor has made to drive the applications of its BIM strategies. All of the formal institutional initiatives are explicated and reviewed on the series of education and training courses. The R&D department of the contractor periodically evaluates the effectiveness of the BIM strategies, particularly referring to those institutional initiatives, through interviews and online surveys. The extent of the fitness between formal and informal institutions can be examined by tracking and checking whether the actual working processes are carried out as designed. When certain conflict is repeatedly reflected by employee(s), the R&D department will follow up the issue with corresponding employee(s) or department(s), and make individual or organisational adjustments when necessary.

This paper reviews the BIM definitions, basic concepts, the development of BIM in the construction industry, and emphasizes the BIM strategies for a contractor in achieving the potential benefits of BIM and enhancing the business competitiveness against its competitors. A case study of a Germany contractor is conducted. Five formal institutional initiatives and three informal institutional initiatives are identified. The findings could serve as a reference for contractors when they are trying to embrace BIM into their business development strategic plans. BIM strategies by pioneering contractor companies should be able to provide considerable guidance and encouragement for other contractors to learn from. For contractors who want to implement BIM in their business, the interplay of formal and informal institutions should be paid close attention in order to achieve the BIM strategies and enhance the business competitiveness in the fiercely competing construction markets.

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