Building Information Model and Supply Chain Integration: A Review

M. Khalfan, H. Khan, and T. Maqsood

***Abstract*—Building Information Modeling (BIM) is emerging as collaborative technology within the construction industry in different parts of the world. BIM then, can be seen as a model that contains information about the entire lifecycle of a building project. This information database and rich information model can be processed with the aid of computer applications. The information is not limited to the building itself but includes components and properties and processes of the building lifecycle. The aim of this paper is to explore the role of BIM in integrating the supply chain on a construction project. The theme could be further explored as a PhD research within the context of Australian construction industry.**

***Index Terms*—Building information model, construction industry, supply chain management.**

I. Introduction

Success factors for integrated collaboration using Building Information Modelling (BIM) can be classified as product information sharing, organisational roles synergy, work processes coordination, environment for teamwork and reference data consolidation [1]. Building information modelling is a process oriented building and infrastructures representation from planning to delivery, ongoing operations and maintenance till recycling of the building. Building information model is a 3D visualization with additional information and data. BIM helped the industry to bring improvements in time, cost and quality [2]. Technology readiness of construction firms is an important factor for innovation due to the changes and improvement in the technology. In relation to construction industry of Malaysia; the construction managers were slow to adapt to changes in technology despite moderate level of technology readiness. One of the reasons for the slow pace is the fragmented nature of the construction industry. Size of construction firms plays an important role in the adoption of technology; big firms are more ready in adoption as compared to smaller firms in Malaysian construction industry. Furthermore investment in human development is also important in the take-off of the Technology [3].

Supply chain management (SCM) is defined as business processes integrating across the supply chain for the purpose of creating value for customers and stakeholders. It involves the flow of materials and services and provides value to customers by optimizing the use of resources [4].Integrated supply chains are required to a greater extent in the construction industry as compared to the manufacturing and process industry. There are similarities existing in the supply chain processes and products of several different industries [5].

The definition of projects as temporary organisations from the angle of organizational theory gives the classical definition a new perspective. Looking at the aims, features, pressures and processes of projects may help us understand and explain the complete definition. Delivery, benefits and change may be categorised as the aims of the project. Project features are novel, unique and transient. Uniqueness means that projects are different from one another and processes will not be repeated in the same way. Projects will start with the end time in mind and can be terminated upon or before completion. Pressure factors may be categorised as uncertainty, integration and transience whereas time, quality and budget are constraints of the projects and their management is important as well. Project deliverables are always uncertain in nature and they may be defined as project outcomes. A project requires integration function in intra project organisation and later in the operations of the firm. Urgency in the achievement of project objectives due to time constraint creates the transience pressures. The processes in projects are different from operations and it needs to be staged, goal oriented and flexible at the same time. Considering projects as a temporary production function help us understand differences between projects, programs and portfolios [6].

Attitude and decision-making behaviour in firms and the resulting culture formation in temporary project organisation are linked. The objective of integration of information is to reduce the fragmentation of information. This objective can be largely achieved where the sub-contractor and the supply chain is adaptive in acquiring new technology. Also due to the temporary nature of project organisation in construction, integration can only be achieved in areas which involves specialist sub-contractors [1].

BIM enables and supports in decision making, rendering projects technologically seamless and divided organisationally [7]. To deliver design, buildings, infrastructure, logistics and supply chain for construction industry, individual players need to perform and communicate in a lean manner to achieve optimum utilization of scarce resources. The same theory can be applied at a national level considering the macro-economic variable in picture. The idea of sustainability and efficiency may be achieved in the integration of supply chain partners by the adoption and implementation of Building Information Model

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(BIM) in a construction project. Further exploration of the "I" in BIM in the use of project management practices and methods being used in today's world may be useful. "I" stands for information in BIM and literature review will help us explain the importance of information sharing, collaboration, analytics and optimization of the information.

II. Literature Review

According to Underwood and Isikdag [8] Building Information Modelling is defined as

"A model of information about building (or building project) that comprise complete or sufficient information to support all lifecycle processes, and which can be directly interpreted by computer applications. It comprises information about the building itself as well as the components, and comprises information about the properties such as function, shape, material and processes for the building lifecycle."

BIM then, can be seen as a model that contains information about the entire lifecycle of a building project. This information database and rich information model can be processed with the aid of computer applications. The information is not limited to the building itself but includes components and properties and processes of the building lifecycle.

A. BIM and Supply Chain Management (SCM)

Opportunities for improvement lie in the innovation of supply chain for construction sector. Construction supply chain performance is dependent on certainty of areas such as time and cost as identified in the UK construction industry [9]. Integrating supply networks improves performance [10] whereas enhanced productivity through BIM may be achieved when processes are reengineered with shared communications [11]. Supply chain management identified in three themes as per extensive literature review which are activities, components and associated benefits. The activities include range of services, finances, flow of material, and networks of internal and external relationships and information. The components include constituents, systems, operations and business functions like purchasing, transportation and organizations involved in supply chain function. Supply chain management benefits are customer satisfaction, value and efficiencies. A consensus on the definition will help us improve our understanding of supply chain management [4] to define construction supply chain which has four particular roles: focus on the interface between supply chain management (SCM) and construction site, focus on supply chain, focus on transferring activities from construction sites to supply chain and focus on integrated management of the supply chain and the construction site. These roles may be exclusive or used jointly on projects. Construction supply chains functionally and structurally are characterised by converging all materials at the site to produce a single product from incoming supplies. The supply chains are temporarily setup for the one off construction project which results in instability and fragmentation. Construction supply chains are also made to order supply chain [12].These four roles of construction supply chain can be improved through the use of BIM. It also improves coordination of supply chains for products and project lifecycles and for its maintenance and operations. When BIM is used with tracking technologies in supply chains, it helps achieve the objectives of Just in time deliveries and installation of material on construction site[13].

Modern buildings are digital in terms of the IT requirements of the occupants as well as systems used to monitor and control the areas of facilities management. Immediate productivity is one of the driving forces for BIM adoption. BIM has the capacity to act as a changing agent in future and as a catalyst which can help BIM vendors to foresee changing industry demands and incorporate sustainability with this. Whole lifecycle Integrated Project Delivery (IPD) approach for information technology was adopted in projects to provide an effective solution to digital buildings [14].

B. Construction Supply Chain Management (CSCM)

The evolution of supply chain management and logistics in the second half of twentieth century has direct impact on the construction supply chain due to its size and importance. Many shortcomings in construction supply chain management sector have been identified by the researchers. They focused on range of issues in construction supply chain management.

Risk management in construction supply chain for projects is identified and framework is given to reduce the gap in project risk management practices in construction projects. Traditionally risk management in construction is about time and cost estimation and probation whereas gap showed the communication of project risks are poorly handled with incomplete information and inconsistencies found[15]. Many firms moved to partnering and alliances arrangement in the construction supply chain with the introduction of lean methodology in construction projects in the first decade of twentieth first century. Skill deficient coupled with attitudes and culture of construction is a barrier to supply chain[16]. The collaborative SCM in the construction sector is not realized to its full potential and level of integration is still lacking in the construction processes[17].

C. BIM Implementation

The construction industry has accepted the Importance of BIM and proposed due importance to BIM integration with social e-business platform [18]. It is concluded through action research, BIM is about people, processes along with technology focusing on engagement and inclusion of all stakeholders towards lean process improvement envisioned and supported by top management[19]. Team commitment is the key factor in the BIM implementation. Overall Plan needs to be devised before implementation to know the goals which can be achieved from this. BIM may facilitate firms to remain competitive, profitable, quality focused, efficient, collaborative and innovative. An important function of a BIM manager is to establish the project database and information flow among teams considering the entire project lifecycle. Implementing BIM workflow will increase productivity. Data communication and ability to exchange information with other partners is very important for collaborative decision making process. IFC facilitated the exchange of digital data and processes in BIM rely on interoperability. Cross functional coordination is vital to all stages of the construction project lifecycle and database should be incorporated in a way where all parties get the required information transparently. Database management is the key component in determining the performance of BIM and primary responsibilities fall on the shoulders of BIM manager. Selection of the BIM tools is very important and it should be aligned with the firm internal and external environment. BIM implementation requires a strategic and tactical approach [20].

Building information modelling introduced over a long period of time and finally acts as a catalyst for change in Architecture, engineering and contractors way of working. Integrated project delivery is based on collaboration between design team, procurement, assets management, construction and knowledge management. BIM is different from the Computer aided design (CAD) as it empowers the stakeholders to visualize any element in the drawing, component and assembly with adjacent component and connections among them. When specification is added to the CAD drawings conceptualization of BIM takes place. BIM has not yet developed an understanding of the physics of force and we are still reliant on the expert opinion. Likewise when BIM matures and artificial intelligence (AI) is able to take advantage of BIM repository of data, the design team work may become obsolete in its existing shape to a great extent. Materials, objects and assemblies when used make a BIM Project, while, Parameters, attributes and constraints speed up the design process. Several standards and formats are used for standardization of information in BIM [21].

Factors which will play vital role in the implementation of BIM are Support of top management, readiness in terms of organisational capability such as coordination and communication and learning curves along technical management [22] whereas Implementing BIM should account for change management and bottom up approach [19]. As a critic it shows that differing opinion exist in the implementation of BIM from management approach.

D. BIM Utilization

One of the objectives of BIM is to improve construction effectiveness. This goal is similar to the goal of computer integrated construction (CIC). Hence guidance should be taken from CIC to understand BIM from a global perspective and in the identification of the effective promising areas and driving factors. The proposed framework is divided into three dimensions of BIM technology, BIM perspective and construction business functions. The technology is grouped into four variables Data Property, Relation, standards and utilization. Perspective dimension is grouped into industry, organisation and project as variables and Construction business function ranging from R&D, general administration, financing, HR management, safety and quality management, cost control and contracting, material management, estimating and scheduling, design, sales and planning [23]. Advances through gaming education in the architectural visualization is proposed by integrating BIM and gaming which will enable designer to play and simulate and user activities in their own designed environment[24].In construction space virtualization(virtual design and construction data management) was introduced two decades ago in partial bits and pieces whereas other industries reckoned the importance and implemented in true spirit since then [25]. BIM may help in teaching construction management in a classroom environment with real virtual simulation in evaluating triple constraint of project management in managing fabrication and construction as well as integrated project management and it also enable to teach change management, integration method for project planning information and optimization of project plans [26].

In construction process improvement is essential for shared knowledge among the stakeholders, ECI (early contractor involvement) for procurement and time management with common grounds of all participants [27]. Enhanced collaboration and integration in supply value chain can be achieved through supplier integration and Fast supply network structure strategy and interaction among them to obtain efficiency, schedule attainment along flexibility [28]. BIM may act as catalyst in knowledge sharing for the low income self-help construction through spatial agency leveraging sustainable construction practices and provision of expert knowledge[29].

Sustainability in building construction may be easily achieved through the use of BIM tool because it readily incorporates all the information required for the sustainability certifications like Leadership in Energy and Environmental Designs (LEED) or at the early stage of design when suitability planning is done. All the data regarding the building is managed through a central repository and required documents for the sake of certification process may be delivered with a lot of convenience though it is not providing a complete solution at this time because of the LEED integration unavailability in BIM based sustainability analyses software's [30]. BIM as central repository for the Building data may help increase safety and emergency response plan through integrating building information with games for simulation like "the serious human rescue game" to avoid clashes and detect security planning in the early stages of fire, earthquake and explosions and its impact on structural damage [31].

In construction supply chain for reinforcement for adoption of BIM, system requirements are defined in terms of capability and performance perspective. Information flow process model is identified for the purpose of improvement and efficiency of the BIM tools capability in the entire reinforcement supply chain because gaps have been found in the implementation of BIM. By analysing adoption rate of BIM between the concrete and reinforced steel industry. It was found that in the steel industry the adoption rate of BIM is increasing over the last decade as opposed to the concrete industry. In the case of reinforced supply chain research body whose focus is on logistics; procurement and fabrication aspects are missing out on the real benefits which can be attained from the BIM capability. The findings of concrete industry strategic development council (SDC) showed that most concrete companies do not use it for coordination, production and construction management activities. The requirement for BIM tools can be classified into four functions for concrete reinforced supply chain as Interoperability; design and modelling; editing and updating; Project and Construction management. Improving the BIM software for adoption by the reinforced industry with the intent to use relevant information for decision making and integrating may fetch the benefits of lower costs, improved shop drawings extracted from central model and schedule optimisation in terms of site and logistics. Hence, BIM's true potential can only be achieved where interoperability and modelling deficiencies are resolved in totality for cross disciplinary collaboration [32].

III. Conclusion

Construction industry as a whole needs totality approach in terms of improvement due to highly integrated nature of the industry. Supply chain partners operate on project to project basis and short term approach is generally seen in the supply chain management as compared to long term approach as adopted in automotive and aviation sectors or other manufacturing sectors. Project management has proved its potential and adoption is accepted by manufacturing industry and services industries. In researcher view adoption of BIM in construction sector may be useful to adopt integrated project delivery in supply chain partners' integration towards IPD/lean construction approach. Communication is one of the key factors of the success of the BIM adoptability and usefulness and it needs to be investigated at all levels.

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