MANAGING ACTORS AND BUILDING INFORMATION FOR SUPPLY CHAIN INTEGRATION

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Abstract. Supply Chain (SC) integration has been a long-standing issue. With the advent of Building Information Modelling (BIM) and its influence on inter-organisational relations, SC integration is again highly relevant. This study explores the conditions for SC integration from deploying BIM and SC management (SCM) philosophy. A set of topics from literature, pertinent to BIM and SCM are confronted with the experiences of experts from the industry during a workshop. The *bottom-up* BIM initiatives and relational management were deemed more decisive than adhering to *top-down* BIM policies and operational SCM for managing actors and information and inciting SC integration.

1. Introduction

Supply Chain (SC) integration has been considered the cornerstone of Supply Chain Management (SCM) philosophy. Across various sectors, the concept of SCM focuses primarily on managing the information and material flows (Vaidyanathan, 2009). In construction, it has been suggested by London and Kenley (2001) that the discussions on SCM and SC integration should move away from the dogma of simply enhancing logistics towards a holistic consideration and particularly under the lens of a network approach. The concept of SC integration in construction in the literature of the United Kingdom (UK) has been a highly disputable concept as it has at times been considered either a precursor of innovation and process improvement (Pryke, 2009) or a hindrance to competitiveness (Fernie and Tennant, 2013).

Recently, with the proliferation of Building Information Modelling (BIM) in Architecture, Engineering, and Construction (AEC) industry, the discussions about SCM and SC integration are again relevant. For example, the market McGraw-Hill report (2012) states that SCM is key activity for

leveraging from BIM. In the UK, the 'intelligent' information flow, derived from BIM models, has been considered as an enabler for SC integration from government reports (CIC, 2011). Thus, the management of the digital information flows could be supported from the set of technologies, applications, and processes that fall under the umbrella of BIM.

Whereas BIM has been mainly associated with design management, it is increasingly acknowledged that it affects many actors in the SC. This study explores the aspects under which BIM could be aligned with SCM and SC partnering, to induce SC integration in AEC. Through an expert workshop in the Netherlands the study discussed the management of actors and building information. The paper is structured as follows. In the ensuing section, the background that leads to the research gap is presented. The methodology and the results are presented next. Finally, the discussion confronts the findings with relevant scientific literature and the concluding section offers a summary of the study and implications for practitioners and researchers.

2. Related work, background and research gap

2.1. ANTECEDENTS FOR SC INTEGRATION

SC integration has been a long-standing issue in AEC. Whereas it has been an enduring and undoubtedly fruitful approach for its financial rewards in the manufacturing industry (Christopher, 2011), it is not uniformly pursued in AEC. For example, in the literature from the UK, SCM, partnering, and efforts for SC integration have been mainly considered a hindrance to competitiveness and the rules of the free market (Fernie and Tennant, 2013). Exceptions include considering SCM and partnering as extra governance structures, e.g. SC framework agreements (Pryke, 2009), to simplify the traditional contracts. After all, originally, the Egan's Report (1998) had envisaged a less formally contractual and a more collaborative industry.

According to London and Kenley (2001) there are two schools of thought for SCM and SC integration in construction; one focusing on the material flows and the optimisation of logistics, and another focusing on holistic approaches to manage the inter-firm relations, e.g. partnering (Lambert et al., 1996). Leuschner et al. (2013) differentiate between operational and relational view of SC integration in SCM research. The operational view of SCM entails activities, such as early involvement of the supplying parties and processual optimisations by applying lean practices, such as co-locations. On the other hand, the relational view of SCM implies some 'soft' aspects, such as increasing the level of trust that inevitably affects how the various inter-organisational actors align. The SC framework agreements are a prerequisite for SCM, as the contracts imply an absence of opportunism

(Williamson, 1985), and could help trust building. Based on the above, managing the actors of the SC implies the deployment of both operational activities, e.g. early (contractual) actor involvement and co-locations, as well as the development of intangible antecedents, such as trust and increased collaboration, which are difficult to be achieved solely by operational means.

2.2. THE PROMISE OF BIM FOR INTEGRATION

BIM has been lately considered a paradigm shift for the AEC. As is it a promising set of technologies for generating, managing, and sharing building information among various project actors, it could undoubtedly improve the information flows in projects. BIM offers benefits in design management (Elmualim and Gilder, 2014) and project management, i.e. time reduction, communication, and coordination improvement (Azhar, 2011), lower costs and fewer returns for information (Bryde et al., 2013). However, the varying capabilities and BIM readiness among the firms result in misunderstandings and poor information management (Mondrup et al., 2012). The collaboration and coordination in BIM-based projects is still a hot topic for the industry, which is approached either from 'bottom-up' or 'top-down' initiatives.

Various 'bottom-up' collaboration approaches have been reported about how the actors engage in BIM. The Open BIM initiative to collaborative design is based on open standards. According to that the actors exchange open rather than native formats under the concept of 'reference models' to coordinate the design (Berlo et al., 2015). Deploying BIM in projects requires increased communications and close collaboration among actors. Any pre-existing trust and close collaboration could, in turn, support better communication. The 'top-down' approaches to regulate BIM collaboration are National initiatives and mandates for controlling BIM features across project phases and prescribe BIM implementation. These initiatives entail quasi-contractual BIM documents among the actors, such as the pre-contract 'BIM Execution Plan' (CPIc, 2013) from the UK, and 'BIM Norm' issued by the Dutch Government Building Agency (GBA) (Rijksgebouwendienst, 2012), both of which are inspired from the Norwegian 'BIM Manual' (Statsbygg, 2011). However, whereas the BIM-related mandates increase across countries, they cannot fully capture the increasing advancements of the BIM technologies and there is a lack of feedback on their performance.

2.3. RESEARCH GAPS AND CONCEPTUAL FRAMEWORK

Based on the above literature, managing the SC actors takes place either via operational or relational approaches. Simultaneously, managing the BIM-

derived building information takes place either ‘bottom-up’ or ‘top-down’. Thus, some key concepts for SC integration pertinent to SCM and BIM are:

- Trust (SCM, relational aspect)
- Early involvement (SCM, operational aspect)
- Co-locations (SCM, operational aspect)
- BIM readiness (BIM, ‘bottom-up’ aspect)
- BIM collaboration (BIM, ‘bottom-up’ aspect)
- BIM protocols (BIM, ‘top-down’ aspect)

The study explores next how these concepts could manage the various multi-disciplinary actors and building information to incite SC integration.

3. Methodology

A qualitative exploratory study was used to discuss the topics emerged from the conceptual model of the previous section, and confront them with the experiences of experts from the industry. The study took place in the Netherlands, where both SCM and BIM concepts have gained a lot of traction the last decade. The idiosyncrasy of the Dutch market could allow for a potential generalisation. As the Dutch AEC has been proactive and consensus-seeking, any lessons-learned from this small market could reflect future trends to larger markets. After all, the Dutch BIM level of maturity is well-advanced, without been subjected to mandatory policies from the Dutch Government Building Agency (GBA), but from ‘bottom-up’ initiatives.

The study drew data from discussions made during a workshop with a group of seven experts. These experts had diverse backgrounds, from both SCM and BIM. Five of them were practitioners from the industry, from which three had more than 25 years of experience in the construction sector. Two of the experts had a research background, but with many years of engagement in ‘consultative research’. The experts welcomed the use of their input for research, but preferred to stay anonymous. The experts and the abbreviations for quick reference (shown in parentheses) are:

- Senior Researcher in SC in Construction (SC Researcher);
- Senior Researcher in BIM (BIM Researcher);
- Regional Director at a large contractor A (Contractor-Director);
- Project Leader at a large contractor B (Contractor-Leader);
- Senior Consultant in Supply Chain integration (SC Consultant);
- Business Manager at a Software Vendor (Software-Manager);
- Senior Engineer at a large consulting firm (Structural Engineer).

The expert workshop lasted about three hours and had the following structure. First, a short presentation of the conceptual model and the six topics were presented (see section 2). Second, the experts reflected on the

aforedescribed topics based on their experience from practice. During the discussion, the experts discussed how these topics could be deployed to achieve SC integration. The discussions were recorded and the recordings were transcribed. The results were analysed qualitatively and are presented next clustered around the main topics, using quotations of the experts.

4. Results and Analysis

4.1. Early actors' involvement

There were two contradictory views about how early supplier involvement could induce SC integration. The SC consultant and the BIM Researcher agreed that it could lead to integration and improve the project if the supplier is treated as 'co-designer'. The Contractor-Director was of the opinion that "*the early involvement is good for the design phase and the engineers*", but not for the realisation phase, as in his company, they "*separate the design from the realisation phase*". Another condition for engaging in early involvement was the alignment of BIM with the project scope, as "*if the project does not fit to one particular SC, they could adjust either the design or change the SC*" (Contractor-Leader). The SC consultant highlighted that early involvement is applicable to "*mature strategic partnerships, where they have to pay the suppliers for their advice under an incentive scheme*."

4.2. Co-location practices, BIM investment, and BIM vision

Overall, the co-location practices were deemed supportive of SC integration from the experts. However, the experts disagreed about whether it was more applicable to mature or young SC partnerships. For the Contractor-Leader, the co-location practices would be supportive of SC integration in all projects and pointed out that the interactions had to be genuinely reciprocal among the actors, otherwise "*some people sit together but do not work together*". The Structural Engineer brought up another important aspect of this strategy, which related to the strategy about BIM investment, and particularly because "*usually the architects do not have a laptop, who pays for those and the rent for the location of the co-locations? […] In a digital setting, you do not have 'small talk'. I think the co-locations can be useful in all projects, but it is most beneficial to practice those in small projects first*".

4.3. Communications and trust

The discussions about trust were contradicting. On the one hand, for the Contractor-Leader and the Software-Manager, all types of intra- and inter-firm communications (also post-project) under complete transparency could incite trust. The Contractor-Director highlighted that "*we should not talk*

only about the bad things. We forgot to do talk about the good things, like our shared vision" (Contractor- Director). On the other hand, for the SC Consultant, not all communications could support SC integration, e.g. "*discussion about price, contracts, and (poor) quality of work do not help to build trust". Discussing the interpretations around a bad contract is bad*" (SC Consultant). The Structural Engineer underlined that the increased communications "*in the early stage are more important to set common BIM goals and planning […] then you see from the beginning the gaps that you face, and then you can resolve them half-way* (Structural Engineer).

4.4. BIM readiness and strategic partners' selection

The experts discussed how the exclusive alignment among firms with similar levels of BIM readiness could induce SC integration. The Contractor-Director stated that for firms with an under-developed BIM level, this alignment could also be beneficial, because it could improve from BIM peer-learning and training. They stated that: "*theoretically, it could be the best option*" (Software-Manager) but "*the aligned SC on the same level is utopia, and this alignment has to take place beyond a project-level*" (Contractor-Leader). The BIM Researcher strongly opposed the alignment of firms based on BIM readiness, as some companies, e.g. the "*concrete supplying companies do not need the same criteria to collaborate with BIM as other actors*". The SC Consultant instead proposed that the "*SC will be weak if the strategic partners are not well advanced in BIM, so the BIM alignment of strategic partners is very important for the integration*" (SC Consultant).

4.5. BIM protocols and scope

In principle, all experts agreed that having BIM protocols could induce SC integration. However, not all experts agreed on the definition of the 'BIM protocols', issued by the Dutch GBA. For example, for the Contractor-Director, the BIM protocol was more a file format and information exchange specifications, while the Structural Engineer viewed them as process prescriptions. The Contractor-Leader emphasised that the BIM protocol "*is more than exchanging files*" and it relates to scope. In practice the BIM protocol "*has nothing to do with the project management plan, because it is not drafted by the person who manages the project*" (Contractor-Leader). Thus, they "*usually do not discuss the protocol properly. […] First, we should plan the logistics, decide if BIM can help, and then have a protocol"* (Contractor-Leader). The BIM Researcher agreed that the "*protocols are made from people who do not know anything about the SC*". To support these discussions the Structural Engineer stated that as the project phase boundaries are obscure at the project start, the BIM protocol should be flexible, and they should "*update the BIM protocol along the way*". The

BIM Researcher also emphasised that "*we probably need different protocols for each project*" (BIM Researcher). The Software-Manager added that the BIM protocols could be a way to communicate the firms' BIM visions. The SC Consultant agreed that "*agreeing on a strategic level about the BIM protocols could reduce costs*" and a "*joint industry protocol would be ideal (…) from the agreements of big companies coming together*".

4.6. BIM-based collaboration

The experts agreed that there are many ways to collaborate with BIM. However, not all ways could "*be beneficial for SC integration*" (Software-Manager). The Contractor-Director suggested that "*with BIM it is all of nothing. You cannot choose to do it 'little BIM', like you can do with SCM*". The Software-Manager emphasised that collaboration with the exchange of reference models with either open or proprietary formats on a Common Data Environment (CDE) could support SC integration. The Contractor-Leader admitted that for BIM: *"we have to learn to work with all the parties. Maybe we should now do things differently. BIM needs to redesign the processes. It takes a long time, and everyone has to be very transparent about what we mean with BIM and how to be efficient"* (Contractor-Leader). Finally, the SC Consultant underscored that similarly with SCM "*there is a lot of opportunistic behaviour in the construction industry about BIM, and many say they are mature, whereas they are very traditional*" (SC Consultant).

5. Discussion

The data suggested two routes for inducing SC integration: managing (a) actors and (b) building information from both operational and relational standpoints. First, for managing the actors, the deployment of operational incentive schemes was deemed important to engage in early actors' involvement (Lambert et al., 1996). Simultaneously, the deployment of relational means, such as increased informal communications, that incite trust, could integrate the actors beyond organisational boundaries (Leuschner et al., 2013). Regarding BIM, the experts agreed that diffusing BIM-related knowledge from various projects across the firms could instigate BIM learning in the SC partnerships, which could in turn support SC integration.

Second, for managing the building information, both 'bottom-up' and 'top-down' approaches were deemed necessary. Consciously aligning the BIM-related investment, such as for digital (CDE) or physical infrastructure, e.g. co-locations with the scope of the SC and the project could increase the afore-described learning experiences of the SC within and beyond projects. However, these 'bottom-up' means to SC integration naturally require a process redesign and re-channeling of the existing information flows. This

redesign could accordingly be partially supported by National 'top-down' policies, such as agreements about BIM protocols and BIM Execution Plans.

During the discussion, the nature and use of the 'BIM protocols' emerged as a key aspect for SC integration. The experts stated that such documents are preeminent for managing the projects; however the protocols could also act as a firm-based BIM vision of the involved firms. This in accordance to the current approach in the UK, where the BIM Execution Plans (CPIc, 2013) are more project-oriented, whereas the CIC BIM Protocols are firm-based and focus on how the various organisations have adopted BIM. That could potentially also be applicable to the Netherlands, where the firms could benefit from separating their BIM visions and the operationalisation of those visions in SC partnerships and projects, within their BIM protocols.

6. Conclusion

The study challenged theoretically and practically concepts derived from literature on BIM and SCM for SC integration. By means of a workshop, industrial experts shared their experiences on BIM and SCM implementation and discussed how the 'top-down' and 'bottom-up' BIM initiatives could support both the project and SC partnerships' scope. From the data, it was deduced that whereas operational and transactional means for SC integration are imperative, e.g. contractual relations and financial incentives, additional relational considerations, e.g. trust-building, increased communication, and joint BIM learning are crucial for integrating the actors. These suggestions for managing both actors and building information flows show a balanced way forward for achieving SC integration. As this study has set up new points for discussion, further research on the prioritisation and fine-tuning of these aspects could focus on BIM process redesign for SC integration.

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