Chapter 2
The Role of Collaboration in the Implementation of BIM–Enabled Projects

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ABSTRACT
The effective undertaking of BIM as a systemic innovation requires tighter collaboration among multiple stakeholders and supply chain partners and entails a culture change. However, obtaining a high degree of collaboration is difficult given the nature of construction projects with a diverse supply chain and stakeholders involved in a project. Therefore, this study focuses on the current improvements and approaches in facilitating the BIM-enabled collaboration as a transformative approach in the built environment.

INTRODUCTION
The implications of digitalisation and automation, by utilising various technologies and processes, such as the Internet of Things (IoT), cloud computing and artificial intelligence (AI) have been the main concern of experts in the manufacturing (Lu, 2017) and Architecture, Engineering, Construction, and Opera-
ations (AECO) industries in terms of Industry 4.0 principles. Industry 4.0 embraces a preponderance of technologies, principles, and methods for increasing the autonomy, dynamism, flexibility, and accuracy of production systems and supply chains (Tortorella & Fettermann, 2018). Information and digital technologies of Industry 4.0 can be used for integration of processes at inter and intra-organisational levels which aims to introduce solutions for requirements of a firm’s digitalisation and automatisation (Xu et al., 2018) within a smart factory paradigm, including interactions between machines (Strozzi et al. 2017).

Moreover, it allows the integration of information throughout the supply chain and the real-time transmission and processing of information for decision making objectives (Novais et al., 2019) in order to maximise value and reduce waste (Deng et al., 2019; Meng, 2020; Bortolini et al., 2019) and to contribute in the lean construction supply chain management. For instance, the use of Computer Aided Design (CAD), Computer Aided Engineering (CAE), Advanced Manufacturing Technologies (AMT and Geographical Information Systems (GIS) in lean construction supply chain (CSC) management processes help the decision making process for supplier selection, determining number of deliveries, and allocation of diverse and scattered consolidation centers (Deng et al., 2019).

Building Information Modelling (BIM) has been contemplated as one of the key technology-centric innovations for the digitalisation of the construction manufacturing context in recent years. Moreover, BIM has been established as a central platform to integrate both the traditional and recent technological advancements in the AECO industries. For example, through integration in the BIM environment, Virtual Reality (VR) and Radio-frequency Identification (RFID) can be used in prefabricated component construction projects (Li et al., 2018). Integrating BIM and VR facilitates production processes to reduce uncertainty and constraints, improve information sharing, and eliminate prefabrication housing production associated reworks (Li et al., 2018).

Additionally, BIM implementation has emerged to improve the collaboration level of the CSC (Deng et al., 2019; Meng, 2020). Concurrently, collaborative efforts of various stakeholders involved in BIM-enabled projects reinforced the BIM implementation process. By the application of BIM in a project, a new collaborative culture should be established in the project environment, which in turn, fosters supply chain and lean-based management in construction practices (Meng, 2020). The synergy in utilization of BIM and SCM decreases the number of and complexities of project tasks to increase overall productivity in construction processes in order to achieve earlier completion dates with the expected quality (Bortolini et al., 2019). However, the fragmented and complexity nature of the construction industry has been frequently cited as one of the most inhibiting factors in improving collaboration.

Nature and Characteristics of AECO Projects and Supply Chain

There is consensus among practitioners that the management of existing social problems linked to physical assets should not be addressed without considering the interactions between assets and the economic, social, and environmental effects of human behavior. This interrelation is followed by substantial challenges owing to fundamental complexities among the elements containing physical built assets and organisational systems used in their diverse phases, such as procurement, delivery, utilization, and disposal.

Complexity is the core characteristic of construction projects through their life cycle from pre-design to recycling and disposal phases. Building projects have diverse interacting and interdependent subsystems such as the network of various actors, the communication networks, and the external environment. To further illustrate this complexity, the procurement of assets contains complicated interactions among diverse stakeholders and organisations operating in supply networks with mutually exclusive perspectives.
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