JBLD, VOL 27, ISSUE NO. 3, 2026. (37 - 52)
@ ARDHI UNIVERSITY, DAR ES SALAAM, TANZANIA

Enhancing the Technology-Organization-Environment Theory for Interorganizational BIM Adoption: A Systematic Review

Rehema J. Monko[1]

ABSTRACT

The adoption of Interorganizational Building Information Modelling in the architecture, engineering, and construction industry remains limited because existing technology adoption theories do not adequately address the collaborative and interdependent nature of projects involving multiple organizations. Although the Technology–Organization–Environment framework is widely used to explain organizational technology adoption, it overlooks the social, interoperability, and legal dimensions required for effective interorganizational collaboration. This study extends the Technology–Organization–Environment framework by integrating these collaborative dimensions to provide a more comprehensive theoretical foundation for Interorganizational Building Information Modelling adoption. A qualitative systematic literature review was conducted using 105 peer-reviewed articles published between 2010 and 2023 and retrieved from Google Scholar, Scopus, and Web of Science. The data were synthesized using descriptive statistical analysis and meta-analysis. The findings show that the traditional technology, organization, and environment dimensions contributed less to Interorganizational Building Information Modelling adoption than the collaborative dimensions of interoperability, legal, and social factors. The study concludes that incorporating these collaborative dimensions into the Technology–Organization–Environment framework strengthens its ability to explain and support interorganizational collaboration and provides a more robust theoretical basis for improving collaborative project delivery in the architecture, engineering, and construction industry.

Keywords: BIM Adoption, TOE Theory, IBIM Model, Interorganizational Context.

INTRODUCTION

Adopting Interorganizational Building Information Modelling (IBIM) yields good results in the architecture, engineering, and construction (AEC) industry but requires an integrated universal theory that adequately categorizes the critical factors within the interorganizational context, which is currently lacking (Azhar, et al., 2008). The most widely used Technology-Organization-Environment (TOE) theory is criticized for lacking interoperability, limited cross-organizational sharing of skills, limited skilled personnel, and low productivity (Jayasena, et al., 2019). IBIM offers many benefits, such as increasing constructability, reducing conflicts, reducing the time required for cost estimation of project implementation, and easing the exchange of information

[1] Dr. Rehema Monko is a member of academic staff at the Department of Building Economics, School of Architecture, Construction, Economics and Management, Ardhi University, P.O. Box 35176, Dar es Salaam. Her is Email Address is : rehema.monko@aru.ac.tz

among construction project players. However, its adoption rate is still low since most of the industry players consider Building Information Modelling as a disruptive technology that necessitates systemic change across organizations, making it difficult to adopt BIM to the fullest extent, particularly in developing countries (Miettinen & Paavola, 2014; Abdirad, 2016; Ahmed, et al., 2017; Hamma-Adama & Kouider, 2018).

The adoption of BIM by the AEC industry stakeholders has been recorded to have tremendous differences between developed countries (mostly the USA and UK) and developing countries, including Malaysia, Ethiopia, Rwanda, and Pakistan. The USA and UK are reported to have higher rates of BIM adoption (>75%) among construction organizations, where BIM has also become mandatory, compared to the developing countries (< 50% adoption) (Won, et al., 2013; Doumbouya, et al., 2016; Aibinu & Papadonikolaki, 2017; Acquah, et al., 2018; Musa, et al., 2018; Musabyimana, et al., 2019; Othman, et al., 2020; Bello, et al., 2022). A low BIM adoption was reported among construction firms in India (22%) and the Middle East, with only 10% of the construction companies implementing BIM in their projects (Bhatti, et al., 2018). This low BIM adoption rate contributes to increasing the cost and time of implementing construction projects in many countries while lowering their social and economic development (Musabyimana, et al., 2019; Shehzad, et al., 2019; Shehzad, et al., 2021).

Adopting IBIM would be a game-changer in the AEC industry as it solves the weaknesses caused by the TOE framework through collaboration of multiple organizations towards construction project implementation (Succar & Kassem, 2015; Murguia, et al., 2017). IBIM provides: ease in project cost estimation, saving project implementation time, ensuring interoperability, solving contractual differences, ensuring well-skilled personnel, sharing of skills and experiences, improved environmental conditions, building trust, social differences agreements, improved productivity, simplicity of information sharing, and improved management decisions (Monko, 2015; Kassem & Succar, 2017; Monko, et al., 2017). Understanding the distinction between organizational and interorganizational BIM factors is, therefore, vital to managing challenges within specific adoption contexts and uses an enhanced TOE theory. However, there is limited adoption (<50% adoption rate) of the Interorganizational Building Information Modelling, accompanied by inadequate knowledge and understanding about IBIM among many AEC organizational managers and staff in most developing countries in the World. For instance, only 60% of AEC industry workers were aware of Interorganizational BIM adoption in African developing countries (Hamma-Adama & Kouider, 2018). This study intends to provide knowledge and build understanding among AEC industry players about IBIM adoption and its related benefits.

Several factors for adopting BIM in an organization have been reported by different researchers, but the technology-organization-environment (TOE) factors have been the most reported factors that affect BIM adoption in an organization. For example, it is stated that TOEs are the main elements that affect firms' adoption of a new technology and are more widely used in terms of new technology adoption (Mohd-Noor, et al., 2018). The technological factors include: complexity, trialability, compatibility, simplicity, credibility, and interoperability (Ahuja, et al., 2016; Alreshidi, et al., 2017; Awa, et al., 2017; Ahuja, et al., 2018; Villena-Manzanares, et al., 2021). Organizational factors comprise; organization support, effective leadership, top management support, organizational culture, and BIM expertise, perceived cost, and organization vision/strategy for instance according to (Aibinu & Papadonikolaki, 2017), top management has to support change; communicate the need for change as well as motivate the entire organization

into change and define the organization's vision for the change, making resources available for implementing change including the building executive team to support the change at all levels. Furthermore, the environment-related factors for BIM adoption at an organizational level include: coercive pressures, mimetic pressures, normative pressures, market forces, supply chain integration, staff's collaborative attitude, client's demand, competitors, suppliers, government and regulatory support, and industry readiness (Rogers, et al., 2015; Doumbouya, et al., 2016; Awa, et al., 2017; Ahuja, et al., 2018; Mohd-Noor, et al., 2018; Al-Ashmori, et al., 2020). The TOE adoption factors are being faced by many challenges, like high cost, contractual, social, and interoperability problems, which hinder most of the organizations from adopting BIM through their construction projects (Ahmed, et al., 2017; Monko, et al., 2017; Musa, et al., 2018; Hochscheid & Halin, 2019; Sinoh, et al., 2020; Al-sarafi, et al., 2022). It, therefore, necessitates the formulation of an alternative framework that integrates both organizational and interorganizational contextual factors.

Different theories like the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), and the Unified Theory of Acceptance and Use of Technology (UTAUT) can be adopted in the AEC industry based on individual or organizational levels of adoption (Yaser, et al., 2016). The TAM theory operates at an individual level based on how the individual user accepts and uses the new technology according to the user's perceptions of the technology's usefulness and ease of use; it is limited to individual user acceptance (Surendran, 2012). The DOI framework operates at both individual, organizational, and societal levels based on the perspective of innovation inherent characteristics and studying the relative advantage, compatibility, complexity, trialability, and observability of the new technology, ideas, or processes to be diffused within and across the AEC population (Yaser, et al., 2016). The UTAUT framework works at an organizational level based on examining the probability of success in the adoption of the new technology while ignoring the external influencing factors. It is limited by the user acceptance and ease of use of the technology at the organizational level (Abbasi, 2011).

MATERIALS AND METHODS

A comprehensive systematic literature review was employed in this research to provide the incorporation between basic factors (technology-organization-environment) and collaborative factors: social-interoperability-legal factors for the adoption of the Interorganizational Building Information Modelling (IBIM). The review was performed according to the procedures adopted from Kitchenham and follows the PRISMA model for a comprehensive and transparent systematic review and meta-analysis based on the Preferred Reporting Items for reviewing and analyzing the relevant publications (Kitchenham & Charters, 2007).

Research Questions

This study utilized the SPICE tool in formulating the research questions (RQs) for facilitating the systematic review and meta-analysis. SPICE (S – Setting: for AEC industry setting; P – Population: for architects, engineers, contractors, quantity surveyors, project managers, and clients; I – Intervention: for IBIM adoption; C – Comparison: for comparing with the existing BIM framework (TOE); and E – Evaluation: for analyzing the strengths of IBIM adoption) tool was used in designing the research questions for initiating the systematic review process. Three (3) research questions (RQ) were formulated: (1) What are the basic factors for Organizational BIM adoption;

(2) What are the collaborative factors for Interorganizational BIM adoption; (3) What is the extent of BIM (IBIM) adoption overlapping factors.

Databases

Google Scholar, Scopus, and Web of Science were the databases applied to explore information for the current study. The databases were selected due to their high availability of reliable literature review articles and open sources in multiple dimensions, including the architecture, engineering, and construction industry. Google Scholar provided a high number of articles (47) compared to the rest (Table 1), implicating its high level of accessibility and reachability. The number of articles obtained was limited by the search criteria and the factors for inclusion and exclusion.

Table 1: Databases and the respective number of articles obtained for systematic review

Database	No. of articles obtained	No. of relevant articles
Google Scholar	109	47
Scopus	57	26
Web of Science	42	16
Total No. of articles	**208**	**89**

Search process

The mixed search strategy was employed, which comprised databases and manual search strategies to access a vast number of relevant publications. The database search strategy was based directly on the search strings and keywords; the manual search strategy was conducted by using the citations and references of the relevant peer-reviewed articles, which were obtained by using the search strings and keywords given in Table 2.

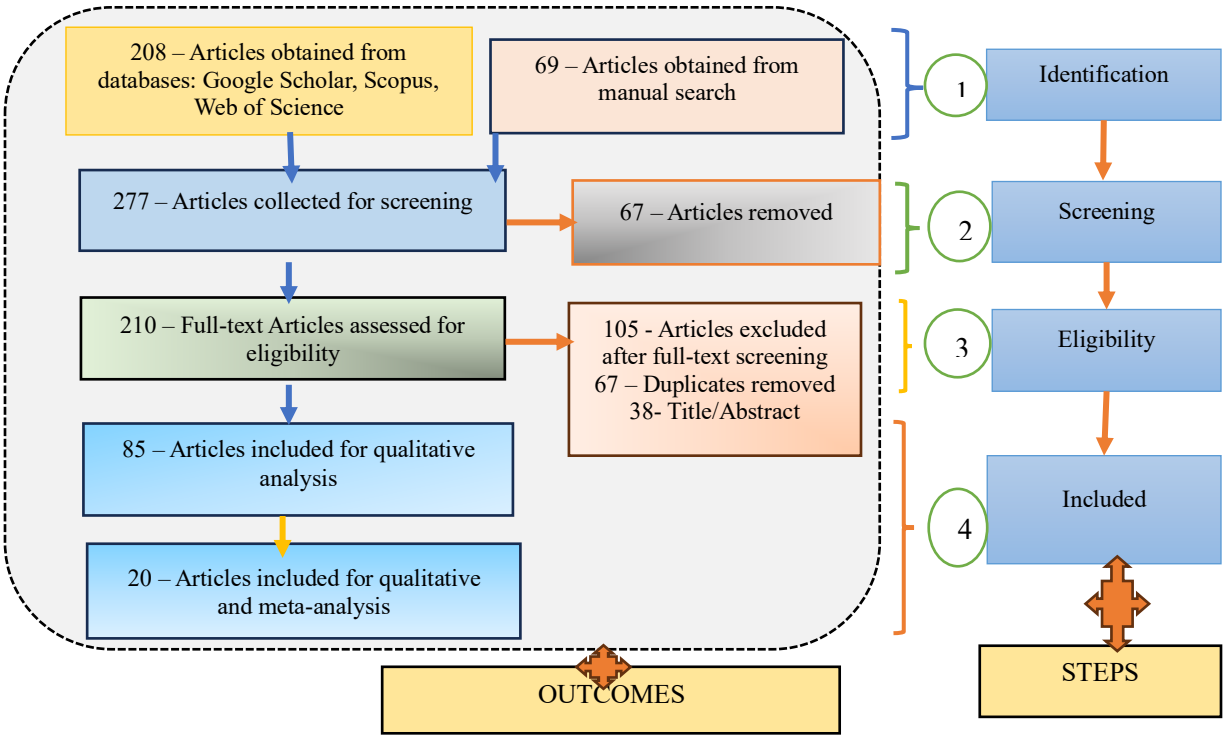


Figure 1: Flow of Articles through different phases of a systematic review and its outcomes as per PRISMA 2009 protocol

A total of 69 papers were obtained through a manual search strategy, whereby 16 papers were included in the review. The search criteria were: (1) BIM and basic factors for BIM adoption or TOE framework; (2) IBIM and collaborative factors for IBIM adoption; and (3) BIM (IBIM) adoption extent measurement. A total of 277 papers were obtained from the databases and manual search and were subjected to a screening process to obtain 105 relevant articles based on the PRISMA 2009 Protocol, as indicated in Figure 1 and Table 3, respectively.

Inclusion and exclusion criteria

Rigorous review of 277 research papers was performed under the following set of inclusion and exclusion criteria: (a) *Article title*: The papers had to focus on organizational/Interorganizational Modeling and adoption context; (b) *Article abstract*: The papers had to focus on aspect of BIM (IBIM) critical factors and/or the Technology-Organization-Environmental, TOE framework, and the IBIM collaborative factors; (c) *Publication year*: The paper had to be published within the recent decade years from 2010 – 2023; (d) *Language*: The paper had to be written in English language; (e) *Journal and conference proceedings type*: The Journals or conference proceedings were to be peer-reviewed and having the contents related to AEC industry; (f) *Duplication limit*: Any papers written by the same author with similar titles were compared to avoid for repetition of idea and results.

Table 2: **The applied Search strings and Keywords in each search criterion**

Search Criteria No.	Search Strings and Keywords
1	"Building Information Modeling" OR "BIM" OR "Building Information Model" OR "TOE framework" OR "Technology-Organization-Environment" OR "Interorganizational Building Modeling" OR "IBIM" OR "Matured BIM" OR "Active BIM" OR "Matured Grounded model" AND "Adoption factors" OR "Implementation factors" OR "Diffusion factors" OR "Diffusion Drivers" OR "BIM Drivers" OR "BIM enablers"
2	"Interorganizational Building Modelling" OR "IBIM" OR "BIM(IBIM) collaboration" OR "BIM collaboration" AND "Adoption factors" OR "Interoperability factor" OR "Contractual factors" OR "Legal factors" OR "Social factors" OR "Implementation factors" OR "Diffusion factors" OR "IBIM Drivers" AND "IBIM Overlapping factors" OR "BIM (IBIM) factors Overlying" OR "BIM(IBIM) enablers"
3	"Interorganizational Building Modelling" OR "IBIM" OR "Interorganizational Building model" AND "IBIM Implementation" OR "IBIM Assessment" OR "IBIM Measurement" OR "IBIM operation"

Quality assessment

The criteria used in assessing the quality of the articles that passed the Initial review were: (i) *Article Source*: The paper had to be obtained from known, reliable databases or search engines; (ii) *Peer-reviewed paper*: The paper had to be peer-reviewed. (iii) *Inclusion- exclusion criteria*: The paper had to meet the review criteria of inclusion and exclusion; and (iv) *Literature search*: The literature search had to likely cover all relevant studies.

Data collection

The Architectural, Engineering, and Building Construction-related publications were the main source of data used in this study. The peer-reviewed papers were collected online from three (3) different databases: Google Scholar, Scopus, and Web of Science based on the following data: (i)

The Main topic area; (ii) The articles' abstract and keywords; (iii) The Main findings of the paper; (iv) Analysis of the BIM (IBIM) Adoption factors; (v) Publication source; (vi) Articles' references; and (vii) The methodology and analysis (Patole, 2021).

Data analysis

Descriptive statistics were used to summarize data in this study, as most of the variables used were qualitative or categorical. Seven (7) themes: BIM (IBIM) overlapping factors, BIM Adoption factors, Building Information Modelling (BIM), IBIM Adoption assessment, IBIM Adoption factors, Interorganizational BIM (IBIM), and Organizational-Interorganizational BIM Integration, and 17 Codes were formulated using NVIVO 14 software from 105 peer-reviewed papers for qualitative and meta-analysis. The Codes (or sub-themes) were formed based on each theme to review the logical content from the included articles.

Table 3: The relevant articles and their publication source are included for qualitative and meta-analysis

Article Source	No. papers	Author + Publication year
Automation in Construction	6	Arayici et al. 2018; Grilo and Jardim-Goncalves 2010; Cao et al. 2015; Succar and Kassem 2015; Kassem and Succar 2017; Miettinen and Paavola 2014
Engineering, Construction, and Architectural Management	5	Rogers et al. 2015; Saka and Chan 2020; Chan et al. 2019; Chen et al. 2019; Sinoh et al. 2020
International Journal of Construction Management	7	Ahuja et al. 2018; Shehzad et al. 2022; Liao and Teo 2019; Le et al. 2022; Khoshfetrat et al. 2022; Awwad et al. 2020; Shehzad et al. 2020
Buildings	4	Sampaio et al. 2023; Cao et al. 2022; Al-sarafi et al. 2022;
International Journal of Project Management	4	Le et al. 2022; Oraee et al. 2017; Papadonikolaki et al. 2019; Bryde et al. 2013
Sustainability (Switzerland)	4	Yuan et al. 2019; Ma et al. 2019; Olanrewaju et al. 2021; Musarat et al. 2023
American Society of Civil Engineers, ASCE	5	Won et al. 2013; Abubakar et al. 2014; Ozorhon and Karahan 2016; Cao et al. 2018; Siebelink et al. 2018
Architectural Engineering and Design Management	4	Saka and Chan 2019; Ahuja et al. 2016; Abdirad 2016; Papadonikolaki et al. 2016
Association of Researchers in Construction Management, ARCOM conference	3	Aibinu and Papadonikolaki 2017; Murguia et al. 2017; Jayasena et al. 2019
AIP Conference Proceedings	2	Musa et al. 2018; Mohammad et al. 2018
International Journal of Construction Engineering and Management	2	Monko et al. 2017; Monko et al. 2017
Architectural Science Review	2	Ayman et al. 2020; Gokuc and Arditi 2017
Journal of Information Technology Management	3	Mohd-Noor et al. 2018; Shehzad et al. 2022; Al-refai et al. 2022; Shehzad et al. 2021
Built Environment Project and Asset Management	2	Ibrahim et al. 2019; Eadie et al. 2015
Journal of Building Engineering	2	Alreshidi et al. 2017; Charef et al. 2019
Frontiers of Engineering Management	2	Hochscheid and Halin 2020; Cao et al. 2017
Ain Shams Engineering and Built Environment	2	Al-Ashmori et al. 2020; Othman et al. 2021

Article Source	No. papers	Author + Publication year
Proceedings of the Joint Conference on Computing in Construction	2	Ahmed et al. 2017; Yilmaz et al. 2017
Engineering, Technology & Applied Science Research	1	Bhatti et al. 2018
International Journal of Civil & Environmental Engineering – IJCEE-IJENS	2	Balah and Akut 2015; Hamma-Adama and Kouider 2018
Renewable and Sustainable Energy Reviews	1	Ghaffarianhoseini et al. 2017
IOP Conference Series: Earth and Environmental Science	1	Mohammad et al. 2018
IOP Conference Series: Materials Science and Engineering	1	Kong et al. 2020
Journal of Physics: Conference Series	1	Al-Ashmori et al. 2020
Emerald Reach Proceedings Series	1	Olowa et al. 2019
Journal of Advances in Civil Engineering	1	Diaz 2016
Construction Management and Economics	1	Davies and Harty 2013
Frontiers in Engineering and Built Environment	1	Magalhaes et al. 2023
Int. J. Engineering Management and Economics	1	Elyamany 2016
Journal of Information Technology in Construction	3	Acquah et al. 2018; Mohammad et al. 2014; Rahman et al. 2019
Cogent Engineering	1	Belay et al. 2023
Journal of Management in Engineering	1	Cao et al. 2018
Other Journals (Related to the AEC industry)	32	Ahmed et al. 2017; Anifowose et al. 2018; Awa et al. 2017; Bello et al. 2022; Chamikara et al. 2023; Chen et al. 2018; Doumbouya et al. 2016; Farook et al. 2019; Hochscheid and Halin 2018; Ibrahim et al. 2019; Kulkami et al. 2021; Liu et al. 2010; Mathews et al. 2018; Mohammad et al. 2016; Mohammad et al. 2020; Mom et al. 2014; Monko 2015; Musabyimana et al. 2019; Mohd-Noor et al. 2018; Sadeghi and Elliott 2019; Saka et al. 2019; Shehzad et al. 2019; Shehzad et al. 2021; Shehzad et al. 2021; Shehzad et al. 2019; Sompolgrunk et al. 2021; Thakur et al. 2015; Usman et al. 2016; Villena-Mnzanares et al. 2021; Wang et al. 2022; Ya'acob et al. 2018; Zahrizan et al. 2013
Total Articles Analyzed	**105**	

The codes formed were: Environmental factors, Organizational factors, Technological factors, Collaborative Interoperability-Legal-Social, Organization-Legal-Environment, Technology-Interoperability-Organization, Technology-Social-Environment, Components of BIM, Description of Building Information Modelling (BIM), BIM adoption, Extent of IBIM Implementation, Interoperability factors, Legal factors, Social factors, Composition of IBIM, Overview of an IBIM, and Description of the BIM (IBIM) Overlapping. Additionally, the meta-analysis was performed

before the codes were formed to cover the RQ3 based on Search Criteria No.3 (Table 2), which were used to indicate the performance of the IBIM adoption context (Abdirad, 2016).

RESULTS AND DISCUSSION

The current study found little research work done within the recent decade, from 2010 to 2023, concerning BIM and/or IBIM adoption as provided in Figure 2. An average of only 8 papers were observed to be published from 2010 to 2023, indicating a dearth of research work on BIM (IBIM) adoption.

IBIM Adoption Factor Integrations

The BIM components for the current study include technological, organizational, and environmental components (TOE), which are also termed the BIM critical adoption factors (Aibinu & Papadonikolaki, 2017). Construction organizations that adopt BIM rely on the sub-components of TOE to allow collaboration among construction organizational workers; for instance, "*the technology–organization–environment (TOE) framework identifies the technology, organization, and environment as the three sets of contextual factors by which an organization adopts the BIM innovations*" (Ahuja, et al., 2016). The basic TOE factors accounted for a total of 34.67% adoption effect for the IBIM model, as indicated in Table 4. This percentage signified the insufficient loophole for TOE factors to allow multiple organizations to share the skills and expertise towards the building and construction projects in the AEC industry.

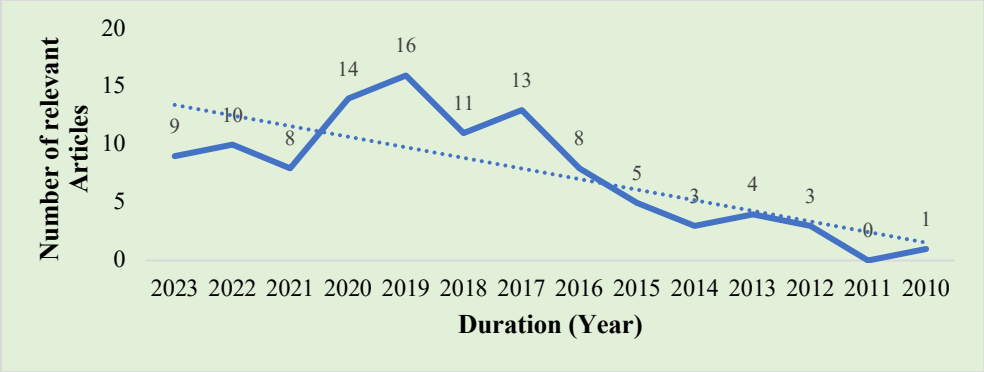


Figure 2: BIM (IBIM) Adoption paper publication trend from 2010 to 2023 years

The IBIM adoption factors in this study are collectively termed as collaborative factors, which are: interoperability, legal, social, overlap of interoperability-legal-social, and integration of TOE with interoperability-legal-and social factors. From Table 4, the collaborative factors contribute to about 65.33% strength towards enhancing AEC firms to adopt the IBIM model. This is twice as much as that contributed by the basic TOE factors; thus, more efforts should be put into these factors to enable AEC firms to adopt the IBIM model. The overlapping factors form seven (7) integration matrices (Figure 4), which generate a theory (IBIM Theory) that enables to solve the challenges related to other models like Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), Technology-Organization-Environment (TOE), and Unified Theory of Acceptance and Use of Technology (UTAUT), like high cost of BIM adoption and insecurity of return on BIM investment (Shehzad, et al., 2021). The formed matrices of IBIM adoption factors influence the improvements of: the willingness to adopt BIM, internal and external factors, cultural differences, legal issues, trialability, BIM quality, cost of project implementation, normative pressure, lack of infrastructure,

resistance to change, incapable BIM professionals, limited government initiatives, lack of awareness, and lack of industry readiness (Ozorhon & Karahan, 2016; Shehzad, et al., 2020; Shehzad, et al., 2021)

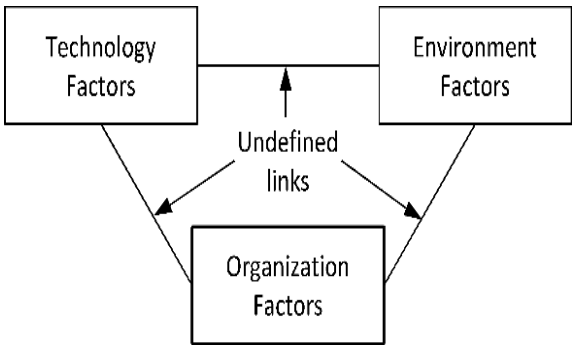


Figure 3: The Technology-Organizational-Environment (TOE) Theory Inadequately Addresses the Interorganizational Level for BIM Adoption

Interoperability Factors (I)

Interoperability factors integrate the technological and organizational factors for IBIM adoption (Figure 4). This overlap describes how the BIM software is interoperable with each other, and how the management and experts are capable of controlling it within the project-responsible firms (Sadeghi & Elliott, 2019; Sampaio, et al., 2023). The Interoperability factors contributed to 26.61% towards IBIM adoption as indicated in Table 4. This is the highest percentage contribution compared to basic TOE factors and collaborative factors, implicating its significance in the adoption of IBIM theory. *Technical interoperability* like open interfaces, connectivity services, data sharing and presentation; *Organizational interoperability* including company objectives, modelling workflows, data sharing among organizations, organizational processes or structures; *Environment interoperability* like user-friendliness, level of expertise, information integration; *Semantic Interoperability* including data source integrations and interpretation; *Legal interoperability* including collaboration of firms in legal frameworks, policies, and agendas (Liu, et al., 2015; Saka & Chan, 2019; Sadeghi & Elliott, 2019; Shehzad, et al., 2021).

Legal Factors (L)

The Legal factors contributed to 25.01% towards IBIM adoption as indicated in Table 4. This is the second-highest percentage contribution compared to basic TOE factors and collaborative factors, implicating its importance in the adoption of IBIM theory. These focus on the contractual agreements within the construction project implementing organizations, integrating the organizational and environmental factors for BIM adoption (Saka & Chan, 2019). The organizations adopting BIM should have mutual statements on legal issues like; model ownership, exposure of trade information, copyright issues, authorization of e-documents, validity, authorized uses of models, skills required, integrated services, service framework, standard remuneration, professional responsibilities, addendum to professional scales of fees, indefatigability of e-documents as evidence, e-contracts, disclaimer clauses, design delegation, data loss, data misuse, intellectual property, BIM interoperability, standardization, value integration, commitment to IT innovation, cyber security (snooping, theft, virus and worms, and hacking), and financial issues, top management decisions, personnel's skills refreshing, effective leadership, visions of the

organizations (Abubakar, et al., 2014; Monko, et al., 2017; Murguia, et al., 2017; Chen, et al., 2018; Saka & Chan, 2020).

Some environmental-related factors for BIM adoption to be integrated with legal issues include: industry status, competitors, access to external resources, and government interaction (Chen, et al., 2018; Saka & Chan, 2019). As the organizations are legally distinct, collaborating in this contractual prohibitive arena (i.e., environmental context) requires addressing legal issues resulting from contractual agreements to protect organizations from potential risks that may discourage full implementation of BIM (Awa, et al., 2017; Awwad, et al., 2020). This requires the legal factor to overlap the organization and environment basic factors, yielding the Organization-Legal-Environment Specific Practice Environment, SPE (Figure 5).

Social Factor (S)

The Societal factors contributed to 13.71% towards IBIM adoption as indicated in Table 4. This is the second-highest percentage contribution compared to basic TOE factors and the third contribution with comparison to collaborative factors, implying that more efforts are required to support its application for the sake of enhancing the adoption of the IBIM theory. The social factors entail the sociological characteristics of and/or around BIM-adopting organizations for construction project implementations. (Monko, et al., 2017) and (Jayasena, et al., 2019) reported that most (90%) of the factors affecting BIM adoption by the AEC organizations are sociological factors that can affect the ways of working and thinking in a lateral rather than linear fashion, and adopting the concept that success or failure is a team responsibility. Some of the sociological factors include: organizational culture, communications, trust, social attitude, team interaction and information sharing, training and cultural issues, and the degree of interdependence, leaving only 10% of technical issues to decide on BIM adoption in most firms (Awa, et al., 2017; Ahuja, et al., 2018; Charef, et al., 2019; Ibrahim, et al., 2019; Shehzad, et al., 2019; Awwad, et al., 2020).

When considering the influence of social factors on IBIM adoption, it is necessary to understand that the structural mechanisms of project-based organizations necessitate that those involved with BIM projects invest in extra coordination to pursue team objectives while enhancing teamwork (Monko, et al., 2017; Ibrahim, et al., 2019; Jayasena, et al., 2019). Accordingly (Monko, et al., 2017), coordinated changes required at an interorganizational level shift traditional approaches to a more collaborative environment, which changes the ways of working and thinking in a lateral, rather than linear, fashion, requiring the social factors of BIM technology to overlap the technology and environment basic factors, yielding the Technology-Social-Environment SPE.

BIM (IBIM) Adoption Measurements

From the 105 fully reviewed papers, the frequencies of 29 technological factors and sub-factors, 40 organizational factors and sub-factors, and 17 environmental factors and sub-factors were observed, which supported the Organizational BIM adoption for the TOE framework, while the frequencies of 66 interoperability factors and sub-factors, 62 legal factors and sub-factors, and 34 social factors and sub-factors were identified, which supported the adoption of Interorganizational BIM (IBIM) theory (Table 3). A total of 78 factors were identified from the reviewed articles, where 29 basic factors constituted 37.18% for BIM adoption and 49 collaborative factors forming 62.82% for IBIM adoption were recognized (Table 4).

The basic factors (TOE) of technology, organization, and environment consisted of the frequencies of 12.82% (10 of 78), 15.38% (12 of 78), and 8.97% (7 of 78), respectively. Although environmental factors appear most infrequently (8.97%), many traditional environmental factors fall under interoperability at the interorganizational level, and a corresponding increase in interoperability factors is evident (Saka & Chan, 2019). Collaborative factors (ILS) with interoperability, legal, and social factors were identified with frequencies of 24.36% (19 of 78), 21.79% (17 of 78), and 16.67% (13 of 78), respectively (Table 4). Although research indicates social factors as the most significant barrier and one that significantly influences the success of BIM adoption, there has been a scarcity of social factor research related to interorganizational BIM adoption (Monko, et al., 2017; Ahuja, et al., 2018). From Table 4, one hundred and seventy (170) sub-factors were identified where the basic (TOE) sub-factors were infrequently identified with a total frequency of 33.53% (57 of 170) and respective frequencies of 11.18% (19 of 170), 16.47% (28 of 170), and 5.88% (10 of 170) where the collaborative (ILS) sub-factors with a total frequency of 66.47% (113 of 170) and respective frequencies of 27.65% (47 of 170), 26.47% (45 of 170), and 12.35% (21 of 170). While sub-factor frequencies are relevant to the development of an IBIMA theory, the sub-factors of organizational variety, team BIM capability, duty of care, risk and liability, scope of work, and data preservation were the recorded critical factors for IBIMA (Monko, et al., 2017).

From the frequencies obtained, most of the organization-related factors (16.13%), followed by the technological awareness factors (11.69%), have stronger influences on Organizational BIM adoption for the AEC industry, while most of the interoperability-related factors (26.61%), followed by the legally related factors (25%), have stronger influences on Interorganizational BIM adoption. However, environmental-related factors and sociological factors are the most limiting factors for organizational BIM and interorganizational BIM adoption, respectively, as correlated with the study done by (Monko, et al., 2017) and (Jayasena, et al., 2019).

IBIMA Theory Generation

The IBIMA theory is generated by integrating *basic factors,* which are consistent with the TOE (technology-organization-environment) theory and *collaborative factors* that relate to interdependency of activities beyond organizational boundaries (interoperability-legal-social), to respectively represent organizational and interorganizational (BIM, IBIM) contexts as indicated in Figures 3 and 4. The IBIMA theory adequately addresses the factors lacking in the TOE theory, while defining their relationship in practice and the literature reviewed. The study contributes to the body of knowledge by extending the Technology-Organization-Environment Theory for Interorganizational BIM Adoption through embracing both the fragmented nature of the construction industry and the unique characteristics of the technologies that involve interdependency of activities at a project level.

Table 4: The frequencies of the Categorical BIMA and IBIMA factors and Sub-factors as adopted from the literatures

Factors	Basic			Collaborative			Total
	T	O	E	I	L	S	
Factor frequency	10 (12.82%)	12 (15.38%)	7 (8.97%)	19 (24.36%)	17 (21.79%)	13 (16.67%)	78
Sub-factor frequency	19 (11.18%)	28 (16.47%)	10 (5.88%)	47 (27.65%)	45 (26.47%)	21 (12.35%)	170
Total Frequency	29 (11.69%)	40 (16.13%)	17 (6.85%)	66 (26.61%)	62 (25%)	34 (13.71%)	248
Most adopted source/s	(Ahuja, et al., 2016;	(Succar & Kassem, 2015;	(Ahuja, et al., 2016;	(Liu, et al., 2015; Saka &	(Abubakar, et al., 2014;	(Awa, et al., 2017; Ahuja,	

	Alreshidi, et al., 2017; Awa, et al., 2017; Ahuja, et al., 2018; Villena-Manzanares, et al., 2021)	Aibinu & Papadonikolaki, 2017)	Alreshidi, et al., 2017; Awa, et al., 2017; Ahuja, et al., 2018; Villena-Manzanares, et al., 2021)	Chan, 2019; Sadeghi & Elliott, 2019; Shehzad, et al., 2021)	Monko, et al., 2017; Murguia, et al., 2017; Chen, et al., 2018; Saka & Chan, 2020)	et al., 2018; Charef, et al., 2019; Ibrahim, et al., 2019; Shehzad, et al., 2019; Awwad, et al., 2020)	

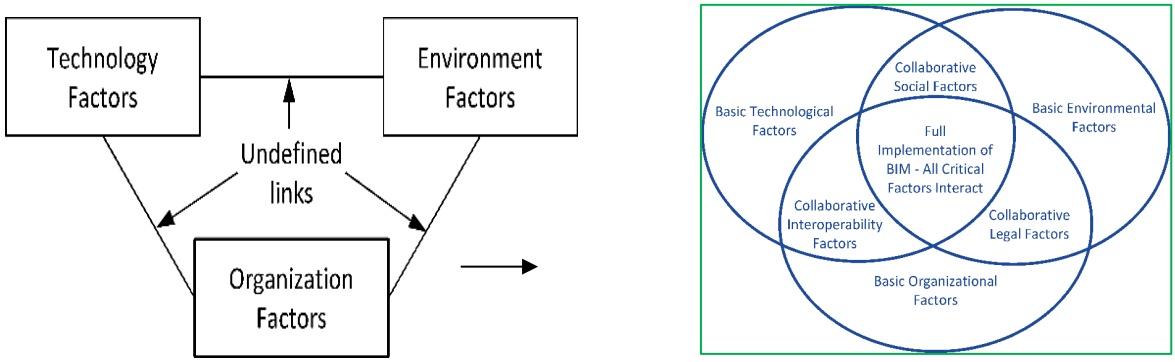


Figure 4: Extending the Technology-Organizational-Environment (TOE) Theory for Interorganizational BIM Adoption

CONCLUSION

This study revealed the presence of weak adoption of the Interorganizational BIM framework, with the Environment (6.9%) and Social (13.7%) factors being recorded as the most limiting factors for the AEC firms to adopt the IBIM theory. Improvements in environment factors at the organization level and social factors at the interorganizational level would enhance the adoption of the IBIM framework. The basic factors of Technology (T) and Organization (O), and the collaborative factors of Interoperability (I) and Legal (L) factors were the most influential factors towards the adoption of IBIM theory within the AEC firms in the developing countries. Investing in providing awareness on these influencing factors would enhance the adoption of IBIM among the AEC organizations. Effective adoption of interorganizational BIM technology necessitates collaboration and systemic change across multiple companies. While (Chau & Tam, 1997) and (Nikas, et al., 2007) both used and modified the TOE theory, the novelty of this present study is the conceptualization and definition of the collaborative factors as links to the basic TOE factors while distinctively representing organizational and interorganizational contexts in an integrated theory.

The current study was limited to reviewing papers that were peer-reviewed and published from 2010 to 2023. The papers included in this study for systematic review were limited to the English language only, thus introducing a chance of bias. Also, the study was based only on systematic reviews towards extending the TOE framework to Interorganizational BIM adoption, thus providing room for future studies. Future studies should be equipped to review studies published within other ranges and covering a specific case-study area like Tanzania, comparing IBIM and TOE frameworks. Other future studies could be conducted to assess the relationship of the IBIM model with sustainable development in developing countries like Tanzania. Additionally, further

studies are encouraged to quantitatively study the fruits of IBIM over other theories like TOE and TAM for AEC firms.

ACKNOWLEDGEMENT

The author gratefully acknowledges the Fulbright Junior Staff Development Program, the Schlumberger Foundation Faculty for the Future Program, and Louisiana State University for support of this study.

REFERENCES

Abbasi, M., 2011. Culture, demography and individuals‟ technology acceptance behaviour: A PLS based structural evaluation of an extended model of technology acceptance in South-Asian country context, s.l.: s.n.

Abdirad, H., 2016. Metric-based BIM implementation assessment: a review of research and practice. Journal of Architectural Engineering and Design Management, pp. 1-27.

Abubakar, M., Ibrahim, Y. M., Kado, D. & Bala, K., 2014. Contractors' Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry. Computing In Civil and Building Engineering, ASCE, 1(1), pp. 167-178.

Acquah, R., Eyiah, A. K. & Oteng, D., 2018. Acceptance of Building Information Modelling: a survey of professionals in the construction industry in Ghana. Journal of Information Technology in Construction (ITcon), Volume 23, pp. 75-91.

Ahmed, A., Kawalek, J. & Kassem, M., 2017. A conceptual Model for investigating BIM adoption by Organizations. Heraklion, Greece, s.n., pp. 447- 455.

Ahuja, R., Jain, M., Sawhney, A. & Arif, M., 2016. Adoption of BIM by architectural firms in India: technology–organization–environment perspective. Architectural Engineering and Design Management, 12(4), pp. 311-330.

Ahuja, R. et al., 2018. Factors influencing BIM adoption in emerging markets—the case of India. International Journal of Construction Management.

Aibinu, A. & Papadonikolaki, E., 2017. The Influence of Leadership, Resources and Organisational Structure on BIM Adoption. Cambridge, UK, Association of Researchers in Construction Management, pp. 12-22.

Al-Ashmori, Y. et al., 2020. BIM benefits and its influence on the BIM implementation in Malaysia.. Ain Shams Engineering Journal.

Alreshidi, E., Mourshed, M. & Rezguia, Y., 2017. Factors for effective BIM governance. Journal of Building Engineering, Volume 10, pp. 89-101.

Al-sarafi, A., Alias, A., Shafri, H. & Jakarni, F., 2022. Factors Affecting BIM Adoption in the Yemeni Construction Industry: A Structural Equation Modelling Approach.. Journal of Buildings, 12(2066), pp. 1-27.

Awa, H., Ukoha, O. & Igwe, S., 2017. Revisiting technology-organization-environment (T-O-E) theory for enriched applicability: The Bottom Line. 30(1), pp. 1-27.

Awwad, K., Shibani, A. & Ghostin, M., 2020. Exploring the critical success factors influencing BIM level 2 implementation in the UK construction industry: the case of SMEs. International Journal of Construction Management.

Azhar, S. A., Mok, J. Y. & Leung, B. Y., 2008. Building Information Modeling (BIM): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects. Karachi, Pakistan, s.n., pp. 435-446.

Bello, A., Abdullahi, M. & Ahmadu, H., 2022. Causal Relationship amongst Risk Factors Impacting the Adoption of Building Information Modeling (BIM) in Nigeria. International Journal of Real Estate Studies, 16(2), pp. 23-33.

Bhatti, I. et al., 2018. Implementation of Building Information Modeling (BIM) in Pakistan Construction Industry. Engineering, Technology & Applied Science Research, 8(4), pp. 3199-3202.

Charef, R., Emmitt, S., Alakaa, H. & Fouchal, F., 2019. Building Information Modelling adoption in the European Union: An overview. Journal of Building Engineering, Volume 25, pp. 1-13.

Chau, P. & Tam, K., 1997. Factors affecting the adoption of open systems: an exploratory study, MIS Quarterly.. pp. 1-24.

Chen, G., Kang, H. & Luna-Reyes, L., 2018. Key Determinants of Online Fiscal Transparency: A Technology-Organization-Environment Framework. Public Performance & Management Review.

Doumbouya, L., Gao, G. & Guan, C., 2016. Adoption of the Building Information Modeling (BIM) for Construction Project Effectiveness: The Review of BIM Benefits. American Journal of Civil Engineering and Architecture, 4(3), pp. 74-79.

Hamma-Adama, M. & Kouider, T., 2018. A review on building information modelling in Nigeria and its potentials. International Journal of Civil and Environmental Engineering, 12(11), pp. 1113-1119.

Hochscheid, E. & Halin, G., 2019. Generic and SME-specific factors that influence the BIM adoption process: an overview that highlights gaps in the literature. Frontiers of Engineering Management.

Ibrahim, F., Shariff, N., Esa, M. & Rahman, R., 2019. The Barriers Factors and Driving Forces for BIM Implementation in Malaysian AEC Companies. Journal of Advanced Research in Dynamical and Control System, 11(8).

Jayasena, H. S., Thurairajah, N., Perera, B. A. & Siriwardena, M., 2019. Promotion of Diffusion of Innovations: A Study of BIM Adoption in Construction Industries. In: Gorse, C and Neilson, C J (Eds). 2-. Leeds, UK, Association of Researchers in Construction Management, pp. 283-292.

Kassem, M. & Succar, B., 2017. Macro BIM adoption: Comparative market analysis. Automation in Construction.

Kitchenham, B. & Charters, S., 2007. Guidelines for performing systematic literature reviews in software engineeringort, s.l.: s.n.

Liu, S., Xie, B., Tivendal, L. & C, L., 2015. Critical Barriers to BIM Implementation in the AEC Industry. International Journal of Marketing Studies, 7(6).

Miettinen, R. & Paavola, S., 2014. Beyond the BIM utopia: Approaches to the development and implementation of building information modeling... Automation in Construction, I(43), pp. 84-91.

Mohd-Noor, S. A., Junaidi, S. & Ramly, M., 2018. Adoption of Building Information Modelling (BIM): Factors Contribution and Benefits. The Everly Putrajaya, Malaysia, s.n., pp. 239-255.

Monko, R., 2015. Interorganizational Collaboration and Systemic Change Framework for Building Information Modeling (BIM) Adoption , s.l.: s.n.

Monko, R., Berryman, C. & Friedland, C., 2017. Critical Factors for Interorganizational Collaboration and Systemic Change in BIM Adoption. International Journal of Construction Engineering and Management, 6(4), pp. 111-132.

Murguia, D., Demian, P. & Soetanto, R., 2017. A Systemic BIM Innovation Model in the Construction Supply Chain. In: Chan, P W and Neilson, C J (Eds). Cambridge, UK, Association of Researchers in Construction Management, pp. 15-24.

Musabyimana, E., Gwaya, A. & Kivaa, T., 2019. Adoption of Building Information Modeling (BIM) on Construction Projects in Rwanda. International Journal of Innovative Science and Modern Engineering (IJISME), 5(12), pp. 1-6.

Musa, S., Marshall-Pointing, A., Nifa, F. & Shahron, S., 2018. Building information modeling (BIM) in Malaysian construction industry: Benefits and future challenges.. s.l., s.n.

Nikas, A., Poulymenakou, A. & Kriaris, P., 2007. Investigating antecedents and drivers affecting the adoption of collaboration technologies in the construction industry. Automation in construction, 16(5).

Othman, I. et al., 2020. The level of Building Information Modelling (BIM) Implementation in Malaysia. Ain Shams Engineering Journal.

Ozorhon, B. & Karahan, U., 2016. Critical Success Factors of Building Information Modeling Implementation. American Society of Civil Engineers.

Patole, S., 2021. Principles and Practice of Systematic Reviews and Meta-Analysis. 1 ed. Cham, Switzerland: Springer.

Rogers, J., Chong, H. & Preece, C., 2015. Adoption of Building Information Modelling technology (BIM). Engineering, Construction and Architectural Management, 22(4), pp. 424-445.

Sadeghi, M. & Elliott, J., 2019. Developing building information models (BIM) for building handover, operation and maintenance. Journal of Facilities Management, 17(3), pp. 301-316.

Saka, A. & Chan, D., 2019. Knowledge, skills and functionalities requirements for quantity surveyors in building information modelling (BIM) work environment: an international Delphi study. Architectural Engineering and Design Management.

Saka, A. & Chan, D., 2020. Adoption and implementation of building information modelling (BIM) in small and medium-sized enterprises (SMEs): a review and conceptualization. Engineering, Construction and Architectural Management, pp. 1-34.

Sampaio, A., Sequeira, P., Gomes, A. & Sanchez-Lite, A., 2023. BIM Methodology in Structural Design: A Practical Case of Collaboration, Coordination, and Integration. Journal of Buildings, 13(31), pp. 1-20.

Shehzad, H. et al., 2021. Determinants of Building Information Modeling Adoption: The case of the Malaysian Construction Industry. Journal of Information Technology Management, pp. 57-82.

Shehzad, H., Ibrahim, R., Yusof, A. & Khaidzir, K., 2019. Building Information Modeling: Factors Affecting the Adoption in the AEC Industry. IEEE.

Shehzad, H. M. et al., 2020. Recent developments of BIM adoption based on categorization, identification and factors: a systematic literature review. International Journal of Construction Management.

Sinoh, S., Othman, F. & Ibrahim, Z., 2020. Critical success factors for BIM implementation: a Malaysian case study. Engineering, Construction and Architectural Management.

Succar, B. & Kassem, M., 2015. Macro-BIM adoption: Conceptual structures. Automation in Construction. Volume 57, pp. 64-79.

Surendran, P., 2012. Technology acceptance model: A survey of literature.. International Journal of Business and Social Research, 2(4), pp. 175-178.

Villena-Manzanares, F., García-Segura, T. & Pellicer, E., 2021. Organizational Factors That Drive to BIM Effectiveness: Technological Learning, Collaborative Culture, and Senior Management Support. Applied Sciences, 11(199), pp. 1-16.

Won, J., Lee, G., Dossick, C. & Messner, J., 2013. Where to Focus for Successful Adoption of Building Information Modeling within Organization. American Society of Civil Engineers, pp. 1-10.

Yaser, H. A., Murad, A., Yahya, A. & Alina, S., 2016. A Critical Review of Models and Theories in Field of Individual Acceptance of Technology. International Journal of Hybrid Information Technology, 9(6), pp. 143-158.