Construction Innovation

A conceptual framework for Industry 4.0 acceptance and adoption in the construction industry: a systematic review

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Abstract

Purpose – Recent technological advancements, also known as Industry 4.0, impact construction processes and, thus, the way people work. Previous research claims that despite extensive research, the implications for people are often overlooked, and the dynamics within an organisation when technology is introduced are widely ignored. This study/paper aimed to develop a conceptual technology acceptance and adoption framework founded on contingent authority innovation adoption theory, the technology organisation environment (TOE) framework and the technology acceptance model (TAM).

Design/methodology/approach – Within the Scopus database, 193 journal publications (in English) were systematically analysed. The systematic literature review was conducted in February 2024, following PRISMA guidelines. The selected articles were content analysed to identify themes, allowing for a robust conceptual framework development.

Findings – The analysis identified 12 factors influencing the management's intention. Under secondary adoption, 20 factors influenced the perceived ease of use, and 17 factors affected the perceived usefulness.

Originality/value – The study presents insights into the acceptance and adoption of technology from an organisational perspective. It provides a comprehensive review of Industry 4.0 acceptance and adoption in the CI, leading to the development of the conceptual framework.

Keywords Conceptual framework, Industry 4.0, Technology acceptance, Technology adoption, Construction industry

Paper type Conceptual paper

1. Introduction

Industry 4.0 (I4.0) in the construction industry (CI), also known as Construction 4.0, has attracted much attention due to its capacity to improve productivity and quality via digitisation, automation and process integration (Oesterreich and Teuteberg, 2016). I4.0 in the CI includes technologies such as 3D printing, artificial intelligence (AI), augmented reality (AR)/virtual reality (VR), building information modelling (BIM), blockchain, cloud computing, digital twins, drones, laser scanners, mobile computing, radio frequency identification (RFID), robotics and sensors (Oesterreich and Teuteberg, 2016; Sawhney *et al.*, 2020; Perera *et al.*, 2023a). Thus, it primarily concentrates on the digital transformation of construction, integrating technology throughout the entire lifecycle of a construction project (Alwashah *et al.*, 2024).

I4.0 is driven by the need to improve product quality, accelerate time to market and enhance organisational performance. Through technical advancements, CI can be made more

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effective and efficient through responsive and dynamic approaches (You and Feng, 2020). For example, using simulation and modelling tools can help improve the early planning stages of a construction project (Darko *et al.*, 2020). Cloud-based platforms make it easier for everyone to access the same information, which helps people make better decisions and communicate more effectively (Bello *et al.*, 2021). Virtual environments and real-time communication tools can help reduce risks and make working together easier (Okoro *et al.*, 2023).

Despite its potential, implementation faces challenges, notably in the acceptance of technology adoption (Oesterreich and Teuteberg, 2016; Müller *et al.*, 2018; Perera *et al.*, 2025). In general, prior studies indicate high rates of new technology adoption failures, ranging between 40% and 60% (Cooper, 1999; Gourville, 2005), with a recent McKinsey survey showing about 70% of digital transformations fail (Bucy *et al.*, 2021). According to Gartner Research, on average, companies lose approximately 20% of their IT budget because of failed technologies (Feld and Stoddard, 2004). Soester (2021) noted that 84% of digital transformation projects fail due to user adoption. Technology acceptance and adoption in the CI are largely reactive compared with proactive measures taken by other industries (Teizer *et al.*, 2013; Oesterreich and Teuteberg, 2016). Therefore, research on technology acceptance and adoption is imperative to unlock the full potential of technological advancements in the CI.

Accordingly, various studies have explored technology acceptance and adoption in the CI. Among these, most of the studies focus on the construction professionals' perspective. As an example, Xue *et al.* (2023a) studied the behaviour of construction employees when adopting smart construction technology, while Zhao *et al.* (2023), Xue *et al.* (2023b), and Mata *et al.* (2024) investigated the professional's perspective of BIM adoption. Researchers have also explored the reasons why management teams adopt new technologies. For instance, Okoro *et al.* (2023) examined management's viewpoint on immersive technology adoption, whereas Wang *et al.* (2020a) surveyed Chinese SME leaders to explore their technology adoption behaviours. Murguia *et al.* (2024) developed a conceptual model for innovation management for the strategic transformation of construction firms. Gledson *et al.* (2024) researched the importance of digital leadership in construction firms, while Ghosh *et al.* (2024) highlighted the need for a managerial shift when technology is adopted. On the other hand, while some studies have looked at how organisations adopt technology (Lin and Xu, 2022; Adeniyi *et al.*, 2024), they do not fully explain why managers make certain decisions or how users respond to new technologies. Existing literature, thus, provides limited insights into the relationship between the initial decisions by an organization to consider and potentially adopt a new technology and the actual implementation and use of the technology within the organization after the initial decision to adopt.

Accordingly, as the first stage of this research, reviewing 150 publications, Perera *et al.* (2023a) established a research gap necessitating the development of a framework to capture the technology acceptance and adoption in the CI from an organisational perspective. This is because early research overlooked organisational dynamics, and studies on management and employee perspectives have not differentiated their roles (Ahmed and Kassem, 2018; Sorce and Issa, 2021). Thus, a question arises as to what factors influence organisations in the CI to accept and adopt technology based on the dynamics between the management and the end users. Accordingly, this paper addresses this research gap by developing a conceptual technology acceptance and adoption framework, considering the organisational perspective and then identifying factors influencing management and end-users through a systematic literature review. By understanding the factors that influence technology acceptance and adoption, organizations in the CI can position themselves to capitalize on the opportunities offered by the I4.0.

2. Literature review

2.1 Theories and models for technology acceptance and adoption

Various models for technology acceptance and technology adoption exist in previous literature, with different scopes and subject matter (Prause and Günther, 2019). Regardless, earlier research has approached this context from three main perspectives: socio-economic (industry level) (Rogers, 2003), managerial (company level) (Gallivan, 2001; Damanpour and Schneider, 2006) and psychological (individual level) (Davis, 1989; Venkatesh *et al.*, 2003). However, within an organisational context, Sepasgozar *et al.* (2016) point out that the effectiveness of technology acceptance and adoption depends on the degree to which it is integrated into the organisation's process, culture and systems rather than the technology itself.

2.1.1 Technology acceptance model. Studies under the psychological cluster have extensively used the Technology Acceptance Model (TAM), which was developed by Davis (1989), as shown in Figure 1. TAM is based on the hypothesis that the acceptance of technology by an individual is governed by their voluntary intention to use it (Yousafzai *et al.*, 2007a). Many scholars have widely acknowledged TAM as the most established model for IT adoption (Alshare *et al.*, 2004; Nnaji *et al.*, 2023). A possible explanation for this gap could be because studies based on TAM often investigated the variables affecting perceived ease of use (PEOU) and perceived usefuleness (PU) of technology and assessed their relationship, demonstrating more flexibility of TAM (Son *et al.*, 2012; Park *et al.*, 2019; Park and Park, 2020).

The model proposes that the intention is primarily determined by attitude, which is mainly affected by two constructs: PEOU and PU, which are influenced by external variables. In this setting, attitude is the users' perceptions regarding the utilisation of technology (Davis *et al.*, 1989). Hence, a clear distinction should be made between usage and technology since a positive view of technology will not necessarily result in favourable use (Yousafzai *et al.*, 2007a).

In the CI, a considerable number of studies have been conducted using TAM. For instance, it has been widely used to investigate the user acceptance and adoption of BIM (Park *et al.*, 2019; Yuan *et al.*, 2019; Mata *et al.*, 2024). While Elshafey *et al.* (2020) investigated the acceptance of BIM and AR integration using TAM, Nnaji *et al.* (2019) incorporated TAM into a simulation framework for decision-making in technology adoption. Wang *et al.* (2022) and Obidallah *et al.* (2024) used TAM to understand the need for blockchain adoption. Using an extension of TAM, Okoro *et al.* (2023) investigated the determinants of immersive technology acceptance. TAM is thus recognised as a widely used model to investigate the user perspective of technology acceptance.

2.1.2 Unified theory of acceptance and use of technology model. Developed by Venkatesh *et al.* (2003) through a comparative analysis of eight TAMs, the Unified theory of acceptance and use of technology (UTAUT) model proposes four core determinants of

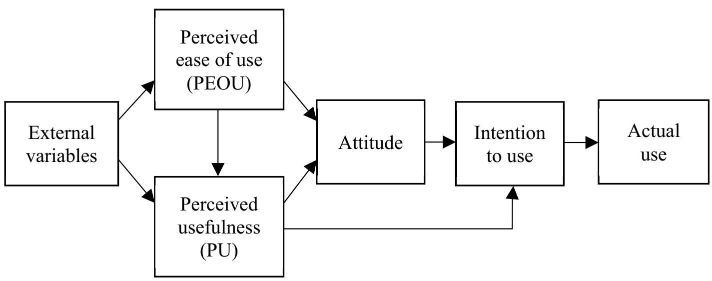

Figure 1. Technology acceptance model (TAM)
Source(s): Adapted from Davis (1989)

intention (performance expectancy, social influence, effort expectancy, facilitating conditions) and four moderators (gender, experience, age and voluntariness) affecting the relationship with behavioural intention and/or user behaviour.

To investigate the digital transformation of the CI, Hewavitharana *et al.* (2021) modified the UTAUT model. Zhang *et al.* (2023b) identified barriers to BIM using an extended UTAUT model. Dowelani and Ozumba (2022) also applied the UTAUT model to determine the adoption of BIM in facilities management in South Africa. Using this model, Chen *et al.* (2020) assessed the willingness to adopt the Internet of Things (IoT) conception in Taiwan's CI. Accordingly, the UTAUT model is another frequently adopted theory in the CI that explains technology acceptance from a psychological perspective.

2.1.3 Innovation diffusion theory. Rogers (1995) proposed innovation diffusion theory (IDT) to explain technology diffusion within a social system. Diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995). The theory thus proposes that diffusion comprises four elements:

(1) characteristics and attributes of innovative technologies (relative advantage, compatibility, complexity, trialability and observability);
(2) communication channels;
(3) time; and
(4) social system.

Accordingly, while the theory explains the decision-making on innovation, it also describes the decision process and determines the factors affecting the adoption rate (Xu *et al.*, 2014). However, Tornatzky and Klein (1982) emphasised that only relative advantage, compatibility and complexity strongly correlate with innovation adoption.

Although TAM focuses on the user's beliefs and IDT explains the diffusion of innovation from an industry perspective, previous literature suggests an overlap between IDT's dimensions and TAM constructs (Chen *et al.*, 2002; Xu *et al.*, 2014). Moore and Benbasat (1991) and Taylor and Todd (1995) acknowledged that PU and PEOU have similar meanings to relative advantage and complexity in IDT. Zhang *et al.* (2008) stated that trialability and observability are closely related to PEOU, as they depend on the user's ability to access the technologies easily. Therefore, although IDT is a frequently used theory in the CI to assess the diffusion of technology adoption, TAM and IDT were found to be often used as mutually complementary (Kim *et al.*, 2016; Ishak and Newton, 2018). For instance, to develop a framework for 3D printing acceptance, Besklubova *et al.* (2024) also combined TAM and IDT. In addition, Haberli *et al.* (2019) combined IDT with the technology organisation environment (TOE) framework to study the adoption of BIM, while Prause and Günther (2019) used the combined theory to investigate the adoption of e-procurement. Therefore, IDT was widely used in research combined with other theories.

2.1.4 Technology-organisation-environment framework. Developed by Tornatzky *et al.* (1990), Technology-Organisation-Environment (TOE) framework conceptualises the innovation process as combining three interconnected elements: technological, organisational and environmental, as shown in Figure 2. Technological factors refer to existing and emerging technologies within and outside the organisation that influence the adoption decision. Thus, when considering the adoption of technologies, an organisation will assess the benefits, characteristics and the extent to which their implementation will enhance its operations (Baker, 2012; Aduwo *et al.*, 2017). Organisational factors are considered to involve assessing the strengths, weaknesses and characteristics. Under environmental factors, opportunities and challenges in the organisation's business ecosystem are considered (Baker, 2012).

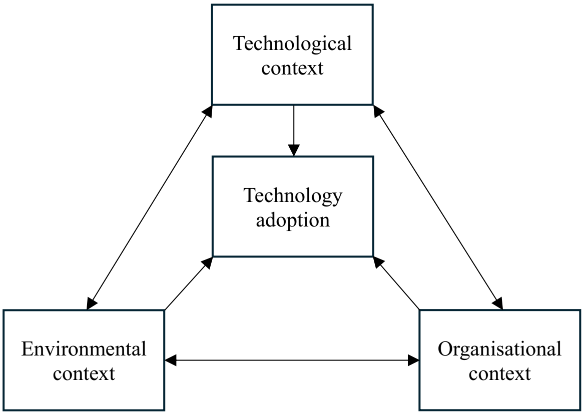

Figure 2. Technology-organisation-environment (TOE) framework
Source(s): Adapted from Tornatzky *et al.* (1990)

Within the context of the CI, Yap *et al.* (2023) used the TOE framework to identify factors affecting the adoption of safety technology, while Amade (2023) used the framework to explore the influence of information and communication technology (ICT). In addition, Luo *et al.* (2023) used the model to investigate digital procurement. Also, studies that used the TOE framework to assess technology adoption in the CI have often combined it with other theories. For instance, Han *et al.* (2024) and Jishnu *et al.* (2024) combined it with the UTAUT model. While Zhang *et al.* (2023a) combined it with IDT, Zhou *et al.* (2023a, 2023b) combined it with TAM to study smart construction technology. Thus, the TOE framework has provided companies with a better understanding of the factors influencing the adoption and implementation of new technologies by examining the three interconnected contexts.

2.1.5 Contingent authority innovation adoption within organisations. Zaltman *et al.* (1973) characterised technological acceptance and adoption in an organisation as a two-stage process: "primary" and "secondary". The "primary" stage focuses on the innovation decision taken at the management level, which is then followed by the "secondary" stage, where the technology to be accepted and adopted by the end-users as depicted in Figure 3 (Leonard-Barton and Deschamps, 1988; Lucas *et al.*, 1990).

Accordingly, steps must be taken to ensure effective secondary adoption once the primary decision is made to adopt the technology. This is because the people's resistance in an organisation is identified as the root cause of change malfunction (Maurer, 1996). Failure of the target users to completely accept the technology results in delays, underutilisation and disruptions (Brown *et al.*, 2002). The theory, thus, emphasises that primary adoption does not necessarily guarantee the successful embrace or use of the innovation by the target users, and this is recognised as what is referred to as the "assimilation gap" (Fichman and Kemerer, 1999).

3. Research methodology

The research was conducted in two phases. Firstly, the research developed a theoretical basis for the conceptual framework. In the study's second phase, a systematic literature review was conducted to expand the conceptual framework by identifying the factors influencing management and end-users to accept and adopt I4.0 in the CI. The process adopted in this research is outlined in Figure 4.

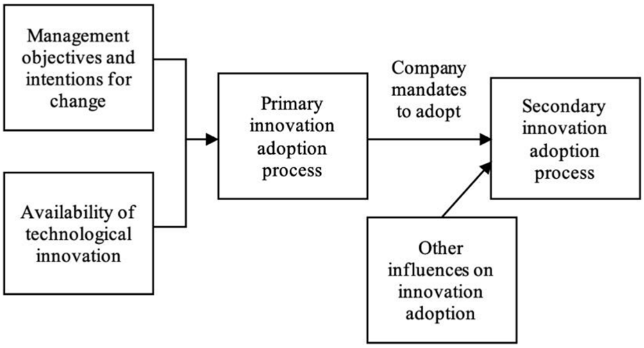

Figure 3. The process of contingent authority innovation adoption within organisations
Source(s): Adapted from Gallivan (2001)

The systematic literature review was conducted in February 2024 following "Preferred reporting items for systematic reviews and meta-analyses (PRISMA)" guidelines. PRISMA method allows the researchers to PRISMA facilitate (1) database search, (2) screening criteria and (3) eligibility appraisal for data analysis (Shahruddin and Zairul, 2020).

For the systematic literature review, it is recommended to use multiple databases to enhance the range of the included studies (Harari *et al.*, 2020). However, numerous studies have focused exclusively on the Scopus database, which is known for its extensive coverage of peer-reviewed literature across various disciplines, including technology, construction and social sciences (Zhong *et al.*, 2019; Nnaji *et al.*, 2020; Wang *et al.*, 2020c; Perera *et al.*, 2022; Perera *et al.*, 2023a). Comparing Scopus and Web of Science databases, Pranckutė (2021) found Scopus provides wider and more inclusive content coverage, eliminating the need to navigate multiple sources and simplifying access to relevant research. Therefore, while other databases may offer complementary information, Scopus was selected as the primary data source due to its expanded scope, credibility, reliability and accessibility, making it the optimal choice for this research (Wuni and Shen, 2020).

The search string ("technology accept*" *OR* "technology adopt*") AND ("construction" *OR* "construction industry") yielded 1181 papers. The study included journal publications in English for their comprehensive and high-quality information. Studies published in languages other than English were excluded due to language limitations and potential translation biases. This review concentrated on peer-reviewed journal articles, as they undergo a rigorous review process that ensures quality and rigour, compared to other forms of publication such as conference papers, industry reports, magazine articles and blogs (Bui *et al.*, 2016; Zhong *et al.*, 2019; Perera *et al.*, 2023b). The screening process yielded 193 publications eligible to develop a conceptual technology acceptance framework to adopt I4.0 in the CI.

The publications that focused on technology acceptance and adoption in the CI, irrespective of I4.0, were included in the study. This is because although I4.0 is a relatively new concept, acceptance of technology in CI is an often studied research area. Nevertheless, technologies unrelated to the study were excluded during the screening process. In addition, three papers (2000, 1999, and 1995) that focused on IT/ICT and did not specify the nature of the technology were removed, given the novelty of I4.0. Accordingly, publications since 2006 were included in this research. The selected articles were then content analysed to identify themes, allowing for a robust conceptual framework development.

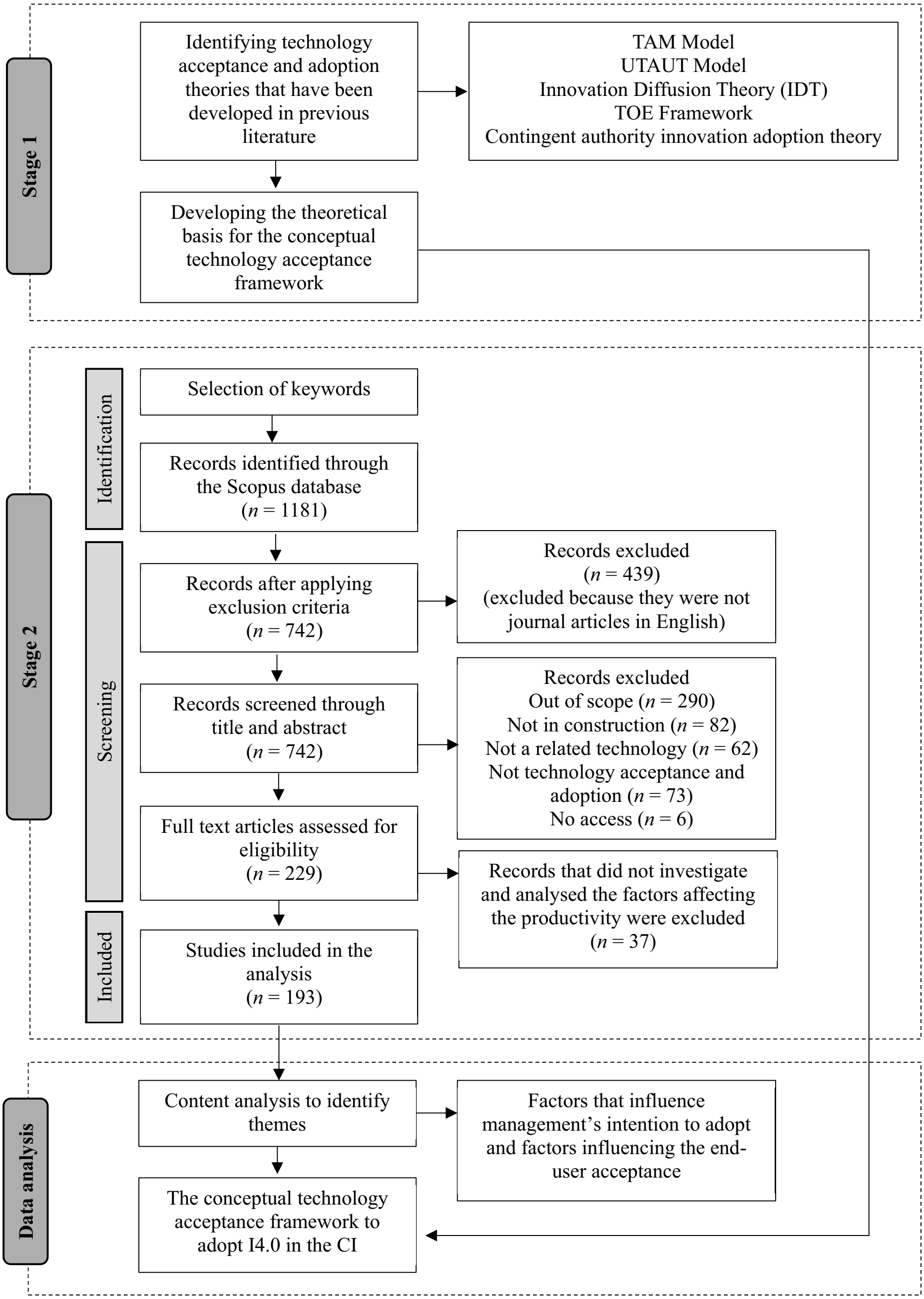

Figure 4. Conceptual framework development process
Source(s): Authors' own work

4. Analysis of the publications by technology and the year

Table 1 shows the nature of the technologies included in this research and their publication year. It can be seen that since 2017, the number of publications in technology acceptance and adoption in the CI has received significant attention, leading up to 53 publications in 2023. Since the study was conducted in early 2024, only a few were included.

Research on technology acceptance and adoption in the CI primarily focuses on BIM, accounting for 36% of the publications. It was also interesting to note that emerging information technology was the second highest, with more than one advanced construction technology investigated. For instance, Ting and Yahaya (2024) focused on the impact of technologies such as BIM, VR, RFID, AR and drones. In their research, Chen *et al.* (2024) studied various digital technologies such as BIM, cloud computing, drones, AI, IoT, sensors, robotics, digital twins and big data. Similarly, Xue *et al.* (2023a) researched the impact of smart construction technology on employees.

5. Technology acceptance and adoption theories in the construction industry

Theoretical models used in the 193 published articles screened through the review to identify the technology acceptance and adoption models used in the CI-related previous literature are presented in Figure 5. These papers are limited to the CI and do not include publications on implementing Industry 4.0 in other industrial settings.

Figure 5 illustrates TAM as the most adopted model (41%), followed by UTAUT (9%). Both models focus on the user, emphasising psychological perspectives. TOE was the most frequently adopted theory in research focusing on technology acceptance and adoption in the CI from an organisation perspective (9%). Findings also revealed that most studies combined theories to explain the context. For example, Aduwo *et al.* (2017) and Saka *et al.* (2020) combined IDT and TOE, while Yuan *et al.* (2019) and Zhao *et al.* (2023) used the TOE framework to expand the TAM. Thus, while these theories stand-alone, combining them was found to enhance contextual understanding.

6. Development of the conceptual framework

6.1 Conceptual framework

Although many scholars use the terms theoretical framework and conceptual framework interchangeably, studies have established that there is a subtle difference (Imenda, 2014). Conceptual models are preliminary representations, while theoretical frameworks are more robust and grounded in established theory. However, a conceptual framework transitions into a theoretical framework when the research substantiates the framework's ability to explain and understand the relationships between variables (Hair *et al.*, 2019). Imenda (2014) also stated that in cases where research problems necessitate a broader perspective than a single theory can provide, researchers might synthesise existing views in the literature. This is often termed a conceptual framework, offering an integrated viewpoint of the problem. Accordingly, this research developed a conceptual model integrating existing theories and frameworks. The term "conceptual framework" will be used in this study because, in future research, the framework will be validated to further explain its relationships.

6.2 Theoretical basis

While many previous studies assess technology acceptance and adoption, Gallivan (2001) and Leonard-Barton and Deschamps (1988) have identified a gap between individual and organisational adoption models. Models from an individual perspective were found to emphasise user autonomy, where adoption is voluntary (Keong *et al.*, 2012), neglecting organisational mandates for technology adoption (Fichman and Kemerer, 1997). In such

Table 1. Analysis of the publications by technology and year

Technology / Year	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
Building information modelling	2	11	14	7	6	9	6	4	5	4	4	1	1						
IT/ICT		2		3	2			2	1				3		2			2	1
Emerging information technology	7	12	5	4	6	1	1			1									
Immersive technology		4	6	6	1														1
Cloud computing	2	4	2	1			2	1	1				1			1		1	
Off-site construction/prefabrication		3	2	1		1	2		1										
Sensor		1	2	3				1											
Smart equipment technology				2		1	1												
Mobile computing/technology					1	1		1											
Big data				2	1	1													
Artificial intelligence (AI)		2	2	2															
Internet of things (IoT)	1	4	1	1	1														
3D printing	2			2															
Robot		1		2															
Radio frequency identification		1		2															
Blockchain	1	5	1																
Industrialised building systems								1											
Drones		1	1																
Digital twin		2		1															
Total	*15*	*53*	*37*	*39*	*18*	*14*	*11*	*10*	*8*	*5*	*4*	*1*	*5*	*0*	*2*	*1*	*0*	*3*	*2*

Source(s): Authors' own work

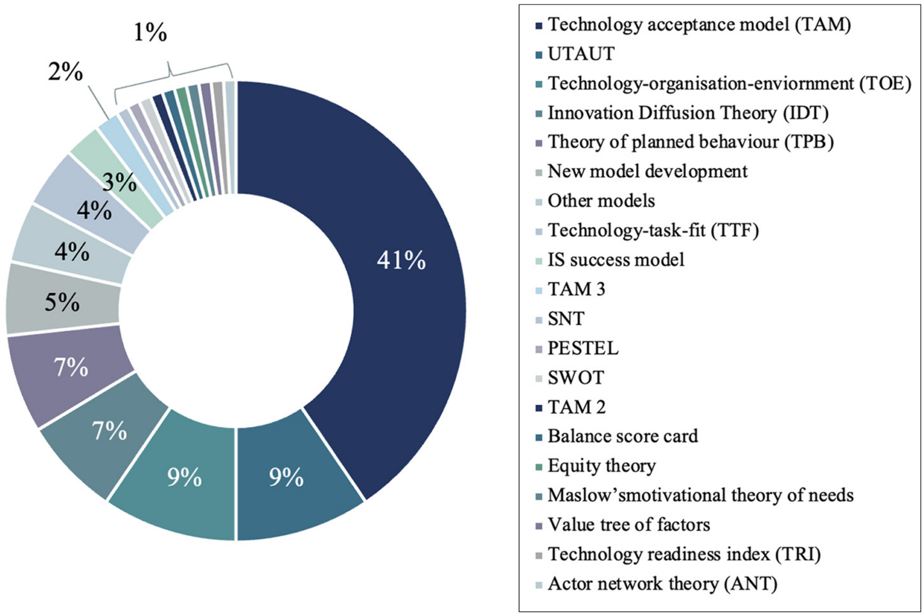

Figure 5. Analysis of publications by the theory adopted
Source(s): Authors' own work

cases, users have limited alternatives and must adapt to new technology for their jobs in a non-voluntary environment (Gallivan, 2001).

Karmakar and Kumar (2021) and Arsene and Constantin (2019) found that top-down I4.0 implementation is crucial in providing the initial push towards the transformation. Therefore, the contingent authority innovation adoption model was considered the most appropriate for explaining the organisational context as it considers both management and user perspectives. However, scholars have argued that the contingent authority innovation adoption model is too simplistic and omits details of "other influences on innovation adoption" (Severijn, 2021). These criticisms led to integration with TAM, renowned for exploring individual acceptance. This is mainly because TAM-based studies often examine the factors influencing technology acceptance and assess their relationships, demonstrating greater adaptability of the framework compared to other theories from the user perspective (Son *et al.*, 2012; Park *et al.*, 2019; Park and Park, 2020). Therefore, TAM was integrated into the conceptual framework to allow for the construct of "other influences" from the contingent authority innovation adoption model to be further explored.

While TAM studies suggest attitude's importance regardless of voluntariness, in mandatory usage, attitude plays a crucial role (Brown *et al.*, 2002; Koh *et al.*, 2010). Involuntary settings diminish the significance of direct "behavioural intention to use" (Adams *et al.*, 1992). Users in such environments have little choice but to accept the technology unless they want to leave the organisation (Leonard-Barton and Deschamps, 1988). Involuntary settings highlight attitude's importance, as failure to accept delays and obstructs implementation. A substantial body of literature, thus, suggests that "attitude" should be used as the key construct when the organisation mandates the use because reactions to innovation are determined by positive and negative attitudes (Yousafzai *et al.*, 2007a, 2007b). Therefore, "attitude" was incorporated in the conceptual framework developed instead of "behavioural intention".

The TOE framework, a widely used integrated analysis framework, is often used to explore the impact of multi-level determinants on new technology implementation (Xue *et al.*, 2023a). Previous literature has established that among the various typically applied theories, only TOE and DOI are commonly used to examine the adoption of IS/IT products and services at the organisational level (Oliveira and Martins, 2011; Li, 2020). However, IDT is more concentrated on technology diffusion within an industry, while TOE considers environmental factors in addition to organisational and technical aspects. The review also found TOE to be the most frequently adopted theory from an organisational perspective. The TOE framework was thus incorporated into the conceptual framework to best explain the effects on the management's intention from an organisation's perspective. The use of the discussed theories in this research is presented in Figure 6.

Consequently, for this research, the conceptual framework was founded on the theory of contingent authority innovation adoption. The TOE framework was incorporated to elaborate on the primary adoption, and TAM was used to explain the secondary adoption. The sections below discuss the factors influencing the management's intention (TOE framework) and the user attitude (TAM).

6.3 Factors influencing the management's intention

Having established the theoretical foundation of the conceptual framework, Table 2 summarises the research findings on the factors influencing the management's intention to adopt I4.0-related technologies in the CI. The review identified 12 factors influencing the management's technology adoption intention, which in turn affects the primary adoption. According to the TOE framework, these can be grouped into three broad categories: technological, organisational and environmental-related factors.

6.4 Factors influencing the user's attitude

The review identified 26 factors influencing users' technology acceptance. Based on the TAM model, these external factors affect PEOU and PU, which then influence the user's attitude

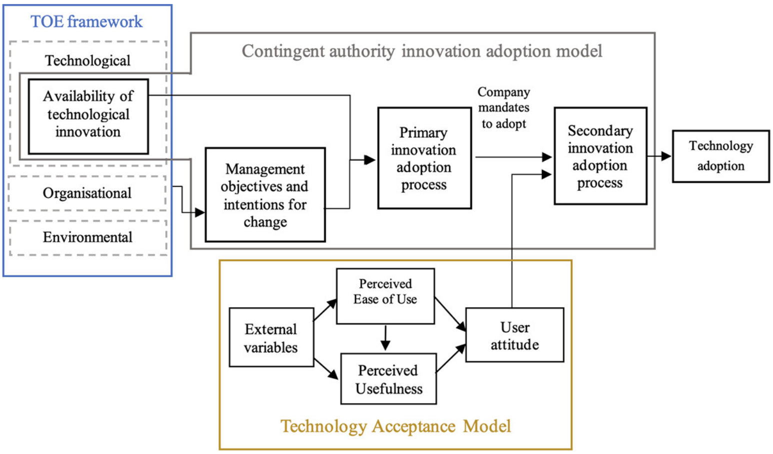

Figure 6. Conceptual framework – literature synthesis
Source(s): Authors' own work

Table 2. Factors influencing the management's intention to adopt

	Factors influencing the management's intention		References
Technology	Compatibility and interoperability	Alignment of the new technology with the work practices and jobs at hand and the ability to integrate with existing technologies for data exchange	Sepasgozar and Davis (2018); Ma *et al.* (2019); Saka *et al.* (2020); Zhou *et al.* (2023a; 2023b)
	Relative advantage/ tangible benefits	Expected improvements in work performance by adopting new technology	Rogers (2003); Sepasgozar and Davis (2018); Wang *et al.* (2020a); Zhou *et al.* (2023a; 2023b)
Organisation	Communication behaviour	Organisation's relationships within and with other parties	Ahmed and Kassem (2018); Ayinla and Adamu (2018); Ma *et al.* (2019)
	Management personality	Management's attitude, leadership/decision-making style, attitude, IT knowledge, involvement and the decision-maker's innovativeness, motivation and beliefs	Hardie *et al.* (2013); Sepasgozar and Davis (2018); Ma *et al.* (2019)
	Characteristics of the organisation	Organisation's size, structure, information system department size, personnel availability to implement and supervise digital innovation, geographical spread, age and ownership nature	Teo *et al.* (2009); Aduwo *et al.* (2017); Wang *et al.* (2020b)
	Organisation's culture	Organisation's corporate management style, the learning and growth perspective, and the organisational attitude toward innovativeness	Cao *et al.* (2014); Mom *et al.* (2014) Saka *et al.* (2020); Zhou *et al.* (2023a; 2023b)
	Organisation's readiness	The preparation status of the firm, including its capacity to adopt innovation	Hardie *et al.* (2013); Ahmed and Kassem (2018); Ma *et al.* (2019); Saka *et al.* (2020); Na *et al.* (2023)
Environment	Client demand	The extent to which a client acts as a driver of technology adoption in a construction project	Hardie *et al.* (2013); Ayinla and Adamu (2018); Nnaji and Karakhan (2020)
	Competition	The extent to which "other companies/professionals", such as direct competitors and partners, use the technology	Teo *et al.* (2003); Ahmed and Kassem (2018); Wang *et al.* (2020a); Zhou *et al.* (2023a; 2023b)
	Government policy and regulations	The level of coercive pressure exerted on companies through government mandates and regulations	Ayinla and Adamu (2018); Yuan *et al.* (2019); Saka *et al.* (2020); Zhao *et al.* (2023)
	Industry influence/social influence	The extent to which the technology remains relevant in the industry	Saka *et al.* (2020); Aghimien *et al.* (2023); Cai *et al.* (2023); Sepasgozar (2023)
	Project nature	Project characteristics including location, complexity, size, duration, project risks, information requirements, the nature of the client, etc	Hardie *et al.* (2013); Ayinla and Adamu (2018); Sepasgozar and Davis (2018); Ma *et al.* (2019); Saka *et al.* (2020)

Source(s): Authors' own work

towards acceptance. While previous studies often categorised individual factors differently, Wang *et al.* (2020b) grouped them into individual, team and project levels. In their study, Xu *et al.* (2014) identified the categories as technology, organisational and attitude dimensions. Chung *et al.* (2009) classified the factors as user-related and project-related variables. However, Yousafzai *et al.* (2007a) conducted a meta-analysis categorising variables into organisational attributes, system attributes, user personal attributes, and others. Therefore, the 26 factors identified in this research were classified under organisational, system, user and project-related factors (Table 3), with 20 influencing PEOU and 17 influencing PU.

6.4.1 Perceived ease of use/effort expectancy. PEOU is referred to as the the level of ease and simplicity that the potential user anticipates from the system (Davis, 1989; Venkatesh *et al.*, 2003). Several studies corroborate PEOU to significantly impact users' attitude/ behaviour (Park *et al.*, 2019; Yuan *et al.*, 2019; Elshafey *et al.*, 2020; Zhao *et al.*, 2023).

6.4.2 Perceived usefulness/performance expectancy. PU refers to an individual's belief that using a particular system will enhance their ability to perform their job duties effectively (Venkatesh *et al.*, 2003). Several researchers validate the influence of PU on attitude or intention (Kim *et al.*, 2016; Choi *et al.*, 2017; Park *et al.*, 2019; Yuan *et al.*, 2019; Zhao *et al.*, 2023).

Previous research further established PEOU to substantially contribute to the PU of the technology, suggesting that if the users find the system easy, the users are more likely to perceive the system as useful (Son *et al.*, 2012; Park *et al.*, 2019; Yuan *et al.*, 2019; Elshafey *et al.*, 2020; Cai *et al.*, 2023).

Section 6.3 outlined 12 factors influencing management's intention for I4.0 adoption in the CI. Section 6.4 then details 26 factors affecting end-user attitude, categorised into organisational, system, user and project-related factors. Incorporating the review findings, Figure 7 illustrates the conceptual technology acceptance framework developed in this study.

7. Conclusion

Successful technology adoption hinges on acceptance. Although many established technology acceptance and adoption models are available, through a systematic literature review, at the outset of this research, Perera *et al.* (2023a) found limitations in existing frameworks to fully capture the organisational dynamics to understand technology acceptance and adoption. Accordingly, this study developed a conceptual model to accept and adopt I4.0 in the CI using the contingent authority innovation adoption theory as the foundation. To elaborate further on the user perspective and the management perspective, TAM and the TOE framework were integrated.

Through a systematic literature review, this study then identified 12 factors influencing management's technology adoption intention (primary adoption). They were compatibility, interoperability, relative advantage, communication behaviour, management's personality, organisational characteristics such as size and structure, age and spread, organisational culture and readiness, client demand, competition, government policy, industry influence and project nature. The study further recognised 26 factors influencing secondary adoption (user acceptance). Among these factors, top management support, compatibility, complexity, perceived enjoyment, trialability, user age, computer anxiety, experience, job relevance, personal competency and consensus on appropriation factors influence both PEOU and PU, while the rest influence either PEOU or PU.

Consequently, this research makes a significant contribution to knowledge by establishing a theoretical foundation for a comprehensive framework for the conceptual technology acceptance framework to adopt I4.0 in the CI. Firstly, it underscores the need to consider both management and user perspectives in technology implementation. Secondly, the research synergises several existing frameworks/theories instead of using

Table 3. Factors influencing the end-user acceptance

Factors influencing the end-user acceptance			PEOU	PU	References
Organisation related	Change management	Change management practices, such as utilising effective change agents, establishing measured benchmarks, and creating a realistic timeframe with technology implementation	X		Gokuc and Arditi (2017); Ayinla and Adamu (2018); Maali *et al.* (2020)
	Facilitating conditions	Organisational and technical resources that are available to facilitate the use of the system. This includes company infrastructure, internet access, ICT equipment, electricity and security	X		Venkatesh *et al.* (2003), Cai *et al.* (2023); Zhao *et al.* (2023); Aghimien *et al.* (2023); Xue *et al.* (2023a; 2023b)
	Level of technical support available	Availability of company support to computer users through instructions, guidance, coaching and consultation in using the technology and the quality of the IT department	X		Nikas *et al.* (2007); Byrd and Turner (2001); Son *et al.* (2012)
	Social influence/peer influence	The level of others expects him/her to use the new system. It also includes forces from superiors or the competitive environment within the organisation to use technology to influence the users		X	Chung *et al.* (2009); Son *et al.* (2015); Choi *et al.* (2017); Lee and Yu (2017); Ishak and Newton (2018); Aghimien *et al.* (2023); Xue *et al.* (2023a; 2023b)
	Top management/ Organisational support	The company management's commitment to employee training and skills development, demonstrates and communicates the technology's usefulness while promoting a positive culture that supports innovation	X	X	Park *et al.* (2012); Son *et al.* (2012); Xu *et al.* (2014); Son *et al.* (2015); Aduwo *et al.* (2017); Park *et al.* (2019); Elshafey *et al.* (2020); Yap *et al.* (2023)
	Training given	The company provided training. This also extends to reactions such as enjoyment, satisfaction and fulfilment of training expectations while creating a conducive training environment	X		Son *et al.* (2012); Xu *et al.* (2014); Ma *et al.* (2019); Baharuddin *et al.* (2020)
Technology related	Compatibility and interoperability	The ability of the technology to (a) exchange data with other systems, (b) be compatible with the job and workstyle, and (c) be integrated into existing processes	X	X	Chung *et al.* (2009); Xu *et al.* (2014); Kim *et al.* (2016); Ishak and Newton (2018); Saka *et al.* (2020); Yap *et al.* (2023)
	The complexity of the technology	The relative difficulty of using and understanding the technology	X	X	Rogers (2003); Cheung and Huang (2005); Son *et al.* (2012); Kim *et al.* (2016); Ishak and Newton (2018); Yap *et al.* (2023); Besklubova *et al.* (2024)
	Observability/ visibility of the results	Ability to observe how others use the technology and its benefits		X	Rogers (2003); Chung *et al.* (2009); Kim *et al.* (2016); Sepasgozar and Davis (2019); Elshafey *et al.* (2020)
	Perceived enjoyment	The technology is perceived as a fun activity	X	X	Park *et al.* (2012); Choi *et al.* (2017); Elshafey *et al.* (2020); Park and Park (2020); Mei *et al.* (2023)

(*continued*)

Table 3. Continued

	Factors influencing the end-user acceptance		PEOU	PU	References
	Perceived risk	Security-related aspects such as privacy and confidentiality		X	Parasuraman and Colby (2015); Choi *et al.* (2017); Aghimien *et al.* (2023)
	Relative advantage/ Perceived value	Capabilities of the technology to benefit the user and the project		X	Sepasgozar and Davis (2018); Hong *et al.* (2019); Almarri *et al.* (2021); Sepasgozar (2021); Cai *et al.* (2023); Besklubova *et al.* (2024)
	System quality	System quality or the display quality and output/information quality		X	Chung *et al.* (2009); Park *et al.* (2012); Park *et al.* (2019); Na *et al.* (2023)
	Trialability	The technology allows users to test it before deciding to adopt it	X	X	Kim *et al.* (2016); Ahmed and Kassem (2018), Ishak and Newton (2018), Besklubova *et al.* (2024)
User-related	Age of the user	The impact of the user’s age on technology acceptance	X	X	Venkatesh *et al.* (2003); Sargent *et al.* (2012); Wang *et al.* (2020a; 2020b; 2020c)
	Computer anxiety	The effect of the user’s computer anxiety on the user’s attitude	X	X	Park *et al.* (2012); Elshafey *et al.* (2020); Ishak and Newton (2018); Mei *et al.* (2023)
	Experience with the technology	The impact of the user’s experience on the user’s attitude	X	X	Venkatesh *et al.* (2003); Venkatesh and Bala (2008); Almarri *et al.* (2021)
	Gender	The degree to which the user’s gender affects the user’s attitude	X		Venkatesh *et al.* (2003); Sargent *et al.* (2012); Wang *et al.* (2020a; 2020b; 2020c)
	Image	The extent to which the users’ prestige and status affect the user’s attitude		X	Chung *et al.* (2009); Elshafey *et al.* (2020)
	Intensity and frequency of actual use	The impact of use frequency on the user’s attitude	X		Ishak and Newton (2018); Gong *et al.* (2019); Park and Park (2020); Igwe *et al.* (2022)
	IT skills/technical competency/ Computer self-efficacy	IT/ICT skills and the user’s capabilities	X		Sargent *et al.* (2012); Son *et al.* (2015); Park and Park (2020); Vigneshwar *et al.* (2022)
	Job relevance	Relevance of the technology to their job	X	X	Chung *et al.* (2009); Son *et al.* (2012); Elshafey *et al.* (2020); Cai *et al.* (2023); Xue *et al.* (2023a; 2023b)
	Openness to data utilisation/ innovation	Openness to experimenting with new technology	X		Xu *et al.* (2014); Lee and Yu (2017); Wang *et al.* (2020a; 2020b; 2020c)
	Perceived control / behavioural power	User’s perspective on the difficulty of enacting a behaviour	X		Barlett (2019); Gong *et al.* (2019); Park *et al.* (2019); Okoro *et al.* (2023)
	Personal competency/self-efficacy	Individual’s confidence in their capability to perform a specific behaviour		X	Hong *et al.* (2019); Wang *et al.* (2020a; 2020b; 2020c), Na *et al.* (2023)
Project-related	Consensus on appropriation	The extent to which individuals agree on jointly using new technology influences the user’s attitude	X	X	Lee and Yu (2016); Lee and Yu (2017); Aladağ *et al.* (2023)

Source(s): Authors’ own work

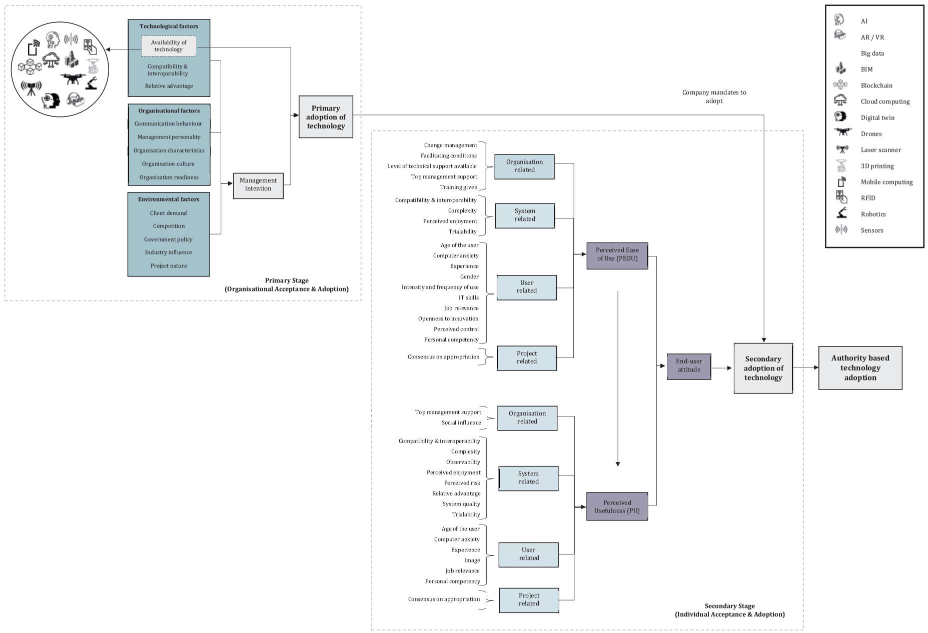

Figure 7. The conceptual technology acceptance framework to adopt industry 4.0 in the construction industry
Source(s): Authors' own work

a single framework/theory. As another noteworthy contribution, the study is the first attempt to develop a framework for I4.0 in the CI, identifying a comprehensive list of influential factors to accept and adopt technology. This study also makes significant contributions to the field of technology acceptance and adoption in the CI. The framework developed in this research can help industry practitioners make informed decisions about I4.0 technology investments. By understanding the key factors influencing adoption, organisations can prioritise their efforts and allocate resources effectively. Thus, this research contributes to the existing knowledge by offering an understanding of how an organization's initial decision to explore and potentially adopt a new technology connects with the subsequent implementation and practical application of that technology.

However, despite reviewing 193 publications, the study's limitation lies in solely using the Scopus database due to its expanded scope, accuracy and user-friendly retrieval compared to other databases. This is, therefore, a limitation of the study. Future research expanding the search could include Web of Science and IEEE Xplore to provide an even more comprehensive analysis of the literature. Additionally, the findings of the study are founded on the literature review and require further validation. Given the theoretical insights in this study, further research could be conducted to validate the framework's applicability using empirical data. For instance, using the developed framework as the basis, future research can be conducted to evaluate if the nature of the technology impacts the influential factors using surveys or case studies. This would enhance the study's practical relevance. Future research could also be conducted to translate this framework into actionable strategies and policy recommendations. It would also be interesting to assess the relationships between the factors identified. Using this study as a starting point, future research could also explore cross-industry technology adoption dynamics.

References

Adams, D.A., Nelson, R.R. and Todd, P.A. (1992), "Perceived usefulness, ease of use, and usage of information technology: a replication", *MIS Quarterly*, Vol. 16 No. 2, pp. 227-247.

Adeniyi, O., Thurairajah, N. and Leo-Olagbaye, F. (2024), "Rethinking digital construction: a study of BIM uptake capability in BIM infant construction industries", *Construction Innovation*, Vol. 24 No. 2, pp. 584-605.

Aduwo, E.B., Ibem, E.O., Ayo-Vaughan, E.A., Uwakonye, U.O. and Owolabi, J.D. (2017), "E-procurement use in the Nigerian building industry", *International Journal of Electronic Commerce Studies*, Vol. 8 No. 2, pp. 219-254.

Aghimien, D., Ikuabe, M., Aliu, J., Aigbavboa, C., Oke, A.E. and Edwards, D.J. (2023), "Empirical scrutiny of the behavioural intention of construction organisations to use unmanned aerial vehicles", *Construction Innovation*, Vol. 23 No. 5, pp. 1075-1094.

Ahmed, A.L. and Kassem, M. (2018), "A unified BIM adoption taxonomy: conceptual development, empirical validation and application", *Automation in Construction*, Vol. 96, pp. 103-127.

Aladağ, H., Demirdöğen, G., Demirbağ, A.T. and Işık, Z. (2023), "Understanding the perception differences on BIM adoption factors across the professions of AEC industry", *Ain Shams Engineering Journal*, Vol. 14 No. 11, pp. 1-13.

Almarri, K., Aljarman, M. and Boussabaine, H. (2021), "Emerging managerial risks from the application of building information modelling", *Journal of Facilities Management*, Vol. 19 No. 2, pp. 228-248.

Alshare, K., Grandon, E. and Miller, D. (2004), "Antecedents of computer technology usage: considerations of the technology acceptance model in the academic environment", *Journal of Computing Sciences in Colleges*, Vol. 19 No. 4, pp. 164-180.

Alwashah, Z., Sweis, G.J., Abu Hajar, H., Abu-Khader, W. and Sweis, R.J. (2024), "Challenges to adopt digital construction technologies in the Jordanian construction industry", *Construction Innovation*, ahead-of-print.

Amade, B. (2023), "Exploring the influence of information and communication technology (ICT) on construction supply chain management: empirical evidence from a construction project's perspective", *Journal of Project Management*, Vol. 8 No. 1, pp. 67-80.

Arsene, C.G. and Constantin, G. (2019), "Industry 4.0: key questions in manufacturing", in Bondrea, I., Cofaru, N.F. and Intă, M. (Eds), *9th International Conference on Manufacturing Science and Education (MSE 2019): Trends in New Industrial Revolution*, *EDP Sciences*, pp. 1-9.

Ayinla, K.O. and Adamu, Z. (2018), "Bridging the digital divide gap in BIM technology adoption", *Engineering, Construction and Architectural Management*, Vol. 25 No. 10, pp. 1398-1416.

Baharuddin, H.E.A., Othman, A.F., Ismail, W.N.W. and Azizi, N.S.M. (2020), "The influence of BIM training on BIM adoption in government agencies", *Malaysian Construction Research Journal*, Vol. 10 No. 2, pp. 93-104.

Baker, J. (2012), "The technology-organization-environment framework", in Dwivedi, Y.K., Wade, M.R. and Schneberger, S.L. (Eds), *Information Systems Theory: integrated Series in Information Systems*, Springer, New York, NY.

Barlett, C.P. (2019), "Social psychology theory extensions", in Barlett, C.P. (Ed.), *Predicting Cyberbullying: research, Theory, and Intervention*, Academic Press, Cambridge, MA.

Bello, S.A., Oyedele, L.O., Akinade, O.O., Bilal, M., Delgado, J.M.D., Akanbi, L.A., Ajayi, A.O. and Owolabi, H.A. (2021), "Cloud computing in construction industry: use cases, benefits and challenges", *Automation in Construction*, Vol. 122, pp. 1-18.

Besklubova, S., Spicek, N., Zhong, R.Y., Kravchenko, E. and J. Kibniewski, M.J. (2024), "A framework for the acceptance of 3D printing technology in construction", *International Journal of Applied Science and Engineering*, Vol. 21 No. 4, pp. 1-25.

Brown, S.A., Massey, A.P., Montoya-Weiss, M.M. and Burkman, J.R. (2002), "Do I really have to? User acceptance of mandated technology", *European Journal of Information Systems*, Vol. 11 No. 4, pp. 283-295.

Bucy, M., Schaninger, B., Vanakin, K. and Weddle, B. (2021), *Losing from Day One: why Even Successful Transformations Fall Short*, McKinsey and Company, New York, NY.

Bui, N., Merschbrock, C. and Munkvold, B.E. (2016), "A review of building information modelling for construction in developing countries", *Procedia Engineering*, Vol. 164, pp. 487-494.

Byrd, T.A. and Turner, D.E. (2001), "An exploratory examination of the relationship between flexible IT infrastructure and competitive advantage", *Information and Management*, Vol. 39 No. 1, pp. 41-52.

Cai, J., Li, Z., Dou, Y., Li, T. and Yuan, M. (2023), "Understanding adoption of high off-site construction level technologies in construction based on the TAM and TTF", *Engineering, Construction and Architectural Management*, Vol. 30 No. 10, pp. 4978-5006.

Cao, D., Li, H. and Wang, G. (2014), "Impacts of isomorphic pressures on BIM adoption in construction projects", *Journal of Construction Engineering and Management*, Vol. 140 No. 12, pp. 1-9.

Chen, L., Gillenson, M.L. and Sherrell, D.L. (2002), "Enticing online consumers: an extended technology acceptance perspective", *Information and Management*, Vol. 39 No. 8, pp. 705-719.

Chen, J.H., Ha, N.T.T., Tai, H.W. and Chang, C.A. (2020), "The willingness to adopt the internet of things (IoT) conception in Taiwan's construction industry", *Journal of Civil Engineering and Management*, Vol. 26 No. 6, pp. 534-550.

Chen, X., Chang-Richards, A.Y., Ling, F.Y.Y., Yiu, T.W., Pelosi, A. and Yang, N. (2024), "Digital technology-enabled AEC project management: practical use cases, deployment patterns and emerging trends", *Engineering, Construction and Architectural Management*, ahead-of-print.

Cheung, W. and Huang, W. (2005), "Proposing a framework to assess internet usage in university education: an empirical investigation from a student's perspective", *British Journal of Educational Technology*, Vol. 36 No. 2, pp. 237-253.

Choi, B., Hwang, S. and Lee, S. (2017), "What drives construction workers' acceptance of wearable technologies in the workplace?: Indoor localization and wearable health devices for occupational safety and health", *Automation in Construction*, Vol. 84, pp. 31-41.

Chung, B.Y., Skibniewski, M.J. and Kwak, Y.H. (2009), "Developing ERP systems success model for the construction industry", *Journal of Construction Engineering and Management*, Vol. 135 No. 3, pp. 207-216.

Cooper, R.G. (1999), *Product Leadership: creating and Launching Superior New Products*, Perseus Books, Cambrige, MA.

Damanpour, F. and Schneider, M. (2006), "Phases of the adoption of innovation in organizations: effects of environment, organization and top managers", *British Journal of Management*, Vol. 17 No. 3, pp. 215-236.

Darko, A., Chan, A.P.C., Yang, Y. and Tetteh, M.O. (2020), "Building information modeling (BIM)-based modular integrated construction risk management – critical survey and future needs", *Computers in Industry*, Vol. 123, pp. 1-15.

Davis, F.D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS Quarterly*, Vol. 13 No. 3, pp. 319-340.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989), "User acceptance of computer technology: a comparison of two theoretical models", *Management Science*, Vol. 35 No. 8, pp. 982-1003.

Dowelani, F. and Ozumba, O. (2022), "Determinants of BIM adoption in facilities management in South Africa: an application of the UTAUT model", *HF-SE*, Vol. 61, pp. 88-96.

Elshafey, A., Saar, C.C., Aminudin, E.B., Gheisari, M. and Usmani, A. (2020), "Technology acceptance model for augmented reality and building information modeling integration in the construction industry", *Journal of Information Technology in Construction*, Vol. 25, pp. 161-172.

Feld, C.S. and Stoddard, D.B. (2004), "Getting IT right", *Harvard Business Review*, Vol. 82 No. 2, pp. 72-79.

Fichman, R.G. and Kemerer, C.F. (1997), "The assimilation of software process innovations: an organizational learning perspective", *Management Science*, Vol. 43 No. 10, pp. 1345-1363.

Fichman, R.G. and Kemerer, C.F. (1999), "The illusory diffusion of innovation: an examination of assimilation gaps", *Information Systems Research*, Vol. 10 No. 3, pp. 255-275.

Gallivan, M.J. (2001), "Organizational adoption and assimilation of complex technological innovations: development and application of a new framework", *ACM SIGMIS Database: The DATABASE for Advances in Information Systems*, Vol. 32 No. 3, pp. 51-85.

Ghosh, A., Abawajy, J. and Chowdhury, M. (2024), "Redefining the construction managerial landscape to facilitate industry 4.0 implementation: scientometric mapping of research frontiers", *Construction Innovation*, Vol. 24 No. 3, pp. 657-683.

Gledson, B., Zulu, S.L., Saad, A.M. and Ponton, H. (2024), "Digital leadership framework to support firm-level digital transformations for construction 4.0", *Construction Innovation*, Vol. 24 No. 1, pp. 341-364.

Gokuc, Y.T. and Arditi, D. (2017), "Adoption of BIM in architectural design firms", *Architectural Science Review*, Vol. 60 No. 6, pp. 483-492.

Gong, P., Zeng, N., Ye, K. and König, M. (2019), "An empirical study on the acceptance of 4D BIM in EPC projects in China", *Sustainability*, Vol. 11 No. 5, pp. 1-19.

Gourville, J.T. (2005), *The Curse of Innovation: A Theory of Why Innovative New Products Fail in the Marketplace*, Harvard Business School, Cambridge, MA.

Haberli, C. Jr, Oliveira, T. and Yanaze, M. (2019), "The adoption stages (evaluation, adoption, and routinisation) of ERP systems with business analytics functionality in the context of farms", *Computers and Electronics in Agriculture*, Vol. 156, pp. 334-348.

Hair, J.F., Page, M. and Brunsveld, N. (2019), "Conceptualization and research design", *Essentials of Business Research Methods*, 4th ed., Routledge, New York.

Han, Y., Zhu, L., Xue, R., Liu, C. and Ding, T. (2024), "Unpacking the dynamics of 3D concrete printing adoption: an integrated UTAUT-TOE approach", *IEEE Transactions on Engineering Management*, Vol. 71, pp. 10716-10726.

Harari, M.B., Parola, H.R., Hartwell, C.J. and Riegelman, A. (2020), "Literature searches in systematic reviews and meta-analyses: a review, evaluation, and recommendations", *Journal of Vocational Behavior*, Vol. 118, p. 103377.

Hardie, M., Allen, J. and Newell, G. (2013), "Environmentally driven technical innovation by Australian construction SMEs", *Smart and Sustainable Built Environment*, Vol. 2 No. 2, pp. 179-191.

Hewavitharana, T., Nanayakkara, S., Perera, A. and Perera, P. (2021), "Modifying the unified theory of acceptance and use of technology (UTAUT) model for the digital transformation of the construction industry from the user perspective", *Informatics*, Vol. 8 No. 4, pp. 1-22.

Hong, S.H., Lee, S.K., Kim, I.H. and Yu, J.H. (2019), "Acceptance model for mobile building information modeling (BIM)", *Applied Sciences*, Vol. 9 No. 18, pp. 1-19.

Igwe, U.S., Mohamed, S.F., Azwarie, M.B.M.D., Ugulu, R.A. and Ajayi, O. (2022), "Acceptance of contemporary technologies for cost management of construction projects", *Journal of Information Technology in Construction (ITcon)*, Vol. 27, pp. 864-883.

Imenda, S. (2014), "Is there a conceptual difference between theoretical and conceptual frameworks?", *Journal of Social Sciences*, Vol. 38 No. 2, pp. 185-195.

Ishak, S.S.M. and Newton, S. (2018), "Testing a model of user resistance towards technology adoption in construction organizations", *International Journal of Innovation and Technology Management*, Vol. 15 No. 6, pp. 1-20.

Jishnu, H.M.A., Anjitha, K.B. and Hareendrakumar, V.R. (2024), "Technology adoption in material procurement: an empirical study applying the UTAUT model among construction companies in India", *Global Business Review*, pp. 1-20.

Karmakar, A. and Kumar, V.S. (2021), "Construction 4.0: what we know and where we are headed?", *Journal of Information Technology in Construction*, Vol. 26, pp. 526-545.

Keong, M.L., Ramayah, T., Kurnia, S. and Chiun, L.M. (2012), "Explaining intention to use an enterprise resource planning (ERP) system: an extension of the UTAUT model", *Business Strategy Series*, Vol. 13 No. 4, pp. 173-180.

Kim, S., Park, C.H. and Chin, S. (2016), "Assessment of BIM acceptance degree of Korean AEC participants", *KSCE Journal of Civil Engineering*, Vol. 20 No. 4, pp. 1163-1177.

Koh, C.E., Prybutok, V.R., Ryan, S.D. and Wu, Y.A. (2010), "A model for mandatory use of software technologies: an integrative approach by applying multiple levels of abstraction of informing science", *Informing Science: The International Journal of an Emerging Transdiscipline*, Vol. 13, pp. 177-203.

Lee, S. and Yu, J. (2016), "Comparative study of BIM acceptance between Korea and the United States", *Journal of Construction Engineering and Management*, Vol. 142 No. 3, pp. 1-9.

Lee, S. and Yu, J. (2017), "Discriminant model of BIM acceptance readiness in a construction organization", *KSCE Journal of Civil Engineering*, Vol. 21 No. 3, pp. 555-564.

Leonard-Barton, D. and Deschamps, I. (1988), "Managerial influence in the implementation of new technology", *Management Science*, Vol. 34 No. 10, pp. 1252-1265.

Li, J.C. (2020), “Roles of individual perception in technology adoption at organization level: behavioral model versus toe framework”, *Journal of System and Management Sciences*, Vol. 10 No. 3, pp. 97-118.

Lin, C.Y. and Xu, N. (2022), “Extended TAM model to explore the factors that affect intention to use AI robotic architects for architectural design”, *Technology Analysis and Strategic Management*, Vol. 34 No. 3, pp. 349-362.

Lucas, H.C. Jr., Ginzberg, M.J. and Schultz, R.L. (1990), *Information Systems Implementation: testing a Structural Model*, Ablex Publishing, Norwood, New Jeret.

Luo, G., Serrão, C., Liang, D. and Zhou, Y. (2023), “A relevance-based technology-organisation-environment model of critical success factors for digital procurement adoption in Chinese construction companies”, *Sustainability*, Vol. 15 No. 16, pp. 1-23.

Ma, G., Jia, J., Ding, J., Shang, S. and Jiang, S. (2019), “Interpretive structural model based factor analysis of BIM adoption in Chinese construction organizations”, *Sustainability*, Vol. 11 No. 7, pp. 1-16.

Maali, O., Lines, B., Smithwick, J., Hurtado, K. and Sullivan, K. (2020), “Change management practices for adopting new technologies in the design and construction industry”, *Journal of Information Technology in Construction*, Vol. 25, pp. 325-341.

Mata, M., Ancheta, R., Batucan, G. and Gonzales, G.G. (2024), “Exploring technology acceptance model with system characteristics to investigate sustainable building information modeling adoption in the architecture, engineering, and construction industry: the case of the Philippines”, *Social Sciences and Humanities Open*, Vol. 10, pp. 1-10.

Maurer, R. (1996), “Transforming resistance: at one time or another, every trainer faces audience resistance”, *Training and Development*, Vol. 50 No. 12, pp. 20-23.

Mei, Y., Liu, J., Jia, L., Wu, H. and Lv, J. (2023), “Exploring the acceptance of the technical disclosure method based on 3D digital technological process by construction workers through the perspective of TAM”, *Buildings*, Vol. 13 No. 10, pp. 1-18.

Mom, M., Tsai, M.H. and Hsieh, S.H. (2014), “Developing critical success factors for the assessment of BIM technology adoption: Part II. Analysis and results”, *Journal of the Chinese Institute of Engineers*, Vol. 37 No. 7, pp. 859-868.

Moore, G.C. and Benbasat, I. (1991), “Development of an instrument to measure the perceptions of adopting an information technology innovation”, *Information Systems Research*, Vol. 2 No. 3, pp. 192-222.

Müller, J.M., Kiel, D. and Voigt, K.I. (2018), “What drives the implementation of industry 4.0? The role of opportunities and challenges in the context of sustainability”, *Sustainability*, Vol. 10 No. 1, pp. 1-24.

Murguia, D., Soetanto, R., Szczygiel, M., Goodier, C.I. and Kavuri, A. (2024), “Construction 4.0 implementation for performance improvement: an innovation management perspective”, *Construction Innovation*, ahead-of-print.

Na, S., Heo, S., Choi, W., Kim, C. and Whang, S.W. (2023), “Artificial intelligence (AI)-based technology adoption in the construction industry: a cross national perspective using the technology acceptance model”, *Buildings*, Vol. 13 No. 10, pp. 1-23.

Nikas, A., Poulymenakou, A. and Kriaris, P. (2007), “Investigating antecedents and drivers affecting the adoption of collaboration technologies in the construction industry”, *Automation in Construction*, Vol. 16 No. 5, pp. 632-641.

Nnaji, C. and Karakhan, A.A. (2020), “Technologies for safety and health management in construction: current use, implementation benefits and limitations, and adoption barriers”, *Journal of Building Engineering*, Vol. 29, pp. 1-11.

Nnaji, C., Gambatese, J., Karakhan, A. and Eseonu, C. (2019), “Influential safety technology adoption predictors in construction”, *Engineering, Construction and Architectural Management*, Vol. 26 No. 11, pp. 2655-2681.

Nnaji, C., Gambatese, J., Karakhan, A. and Osei-Kyei, R. (2020), "Development and application of safety technology adoption decision-making tool", *Journal of Construction Engineering and Management*, Vol. 146 No. 4, pp. 1-15.

Nnaji, C., Okpala, I., Awolusi, I. and Gambatese, J. (2023), "A systematic review of technology acceptance models and theories in construction research", *Journal of Information Technology in Construction*, Vol. 28, pp. 39-69.

Obidallah, W.J., Rashideh, W., Kamaruddeen, A.M., Alzahrani, T., Alduraywish, Y., Alsahli, A. and Alshuqayran, N. (2024), "Beyond the hype: a TAM-based analysis of blockchain adoption drivers in construction industry", *Heliyon*, Vol. 10 No. 19, p. e38522.

Oesterreich, T.D. and Teuteberg, F. (2016), "Understanding the implications of digitisation and automation in the context of industry 4.0: a triangulation approach and elements of a research agenda for the construction industry", *Computers in Industry*, Vol. 83, pp. 121-139.

Okoro, C.S., Nnaji, C. and Adediran, A. (2023), "Determinants of immersive technology acceptance in the construction industry: management perspective", *Engineering, Construction and Architectural Management*, Vol. 30 No. 7, pp. 2645-2668.

Oliveira, T. and Martins, M.F. (2011), "Literature review of information technology adoption models at firm level", *Electronic Journal of Information Systems Evaluation*, Vol. 14 No. 1, pp. 110-121.

Parasuraman, A. and Colby, C.L. (2015), "An updated and streamlined technology readiness index: TRI 2.0", *Journal of Service Research*, Vol. 18 No. 1, pp. 59-74.

Park, E.S. and Park, M.S. (2020), "Factors of the technology acceptance model for construction IT", *Applied Sciences*, Vol. 10 No. 22, pp. 1-15.

Park, Y., Son, H. and Kim, C. (2012), "Investigating the determinants of construction professionals' acceptance of web-based training: an extension of the technology acceptance model", *Automation in Construction*, Vol. 22, pp. 377-386.

Park, E., Kwon, S.J. and Han, J. (2019), "Antecedents of the adoption of building information modeling technology in Korea", *Engineering, Construction and Architectural Management*, Vol. 26 No. 8, pp. 1735-1749.

Perera, C.S.R., Francis, V. and Shang, G. (2023a), "Acceptance and adoption of construction 4.0-related technology", in Tutesigensi, A. and Neilson, C.J. (Eds), *39th Annual Association of Researchers in Construction Management (ARCOM) Conference, Leeds, UK, ARCOM*, pp. 426-435.

Perera, C.S.R., Francis, V. and Gao, S. (2025), "Uptake of industry 4.0 technologies in Australian construction firms", *Engineering, Construction and Architectural Management*, ahead-of-print.

Perera, C.S.R., Gao, S., Manu, P., Francis, V. and Urhal, P. (2022), "Unmanned aerial vehicles (UAV) for safety in the construction industry: a systematic literature review", *IOP Conference Series: Earth and Environmental Science*, Vol. 1101 No. 9, pp. 1-10.

Perera, S., Paton-Cole, V., Gao, S., Francis, V., Urhal, P., Manu, P., Bartolo, P.J.D.S., Cheung, C., Yunusa-Kaltungo, A. and Babalola, A. (2023b), "Artificial intelligence for occupational health and safety management in construction: a systematic review", in Manu, P., Shang, G., Bartolo, P.J.S., Francis, V. and Sawhney, A. (Eds), *Handbook of Construction Safety, Health and Well-Being in the Industry 4.0 Era*, 1st ed., Routledge, London.

Pranckutė, R. (2021), "Web of science (WoS) and Scopus: the titans of bibliographic information in today's academic world", *Publications*, Vol. 9 No. 1, p. 12.

Prause, M. and Günther, C. (2019), "Technology diffusion of industry 4.0: an agent-based approach", *International Journal of Computational Economics and Econometrics*, Vol. 9 Nos 1/2, pp. 29-48.

Rogers, E.M. (1995), *Diffusion of Innovations*, 4th ed., Free Press, New York, NY.

Rogers, E.M. (2003), *Diffusion of Innovations*, 5th ed., Free Press, New York, NY.

Saka, A.B., Chan, D.W.M. and Siu, F.M.F. (2020), "Drivers of sustainable adoption of building information modelling (BIM) in the Nigerian construction small and medium-sized enterprises (SMEs)", *Sustainability*, Vol. 12 No. 9, pp. 1-23.

Sargent, K., Hyland, P. and Sawang, S. (2012), "Factors influencing the adoption of information technology in a construction business", *Construction Economics and Building*, Vol. 12 No. 2, pp. 72-86.

Sawhney, A., Riley, M. and Irizarry, J. (Eds) (2020), *Construction 4.0: An Innovation Platform for the Built Environment*, Routledge, London.

Sepasgozar, S.M.E. (2021), "Digital technology utilisation decisions for facilitating the implementation of industry 4.0 technologies", *Construction Innovation*, Vol. 21 No. 3, pp. 476-489.

Sepasgozar, S.M.E. (2023), "Construction digital technology assimilation and absorption capability using measurement invariance of composite modeling", *Journal of Construction Engineering and Management*, Vol. 149 No. 7, pp. 1-14.

Sepasgozar, S.M.E. and Davis, S. (2018), "Construction technology adoption cube: an investigation on process, factors, barriers, drivers and decision makers using NVivo and AHP analysis", *Buildings*, Vol. 8 No. 6, pp. 1-31.

Sepasgozar, S.M.E. and Davis, S. (2019), "Digital construction technology and job-site equipment demonstration: modelling relationship strategies for technology adoption", *Buildings*, Vol. 9 No. 7, pp. 1-33.

Sepasgozar, S.M.E., Loosemore, M. and Davis, S.R. (2016), "Conceptualising information and equipment technology adoption in construction: a critical review of existing research", *Engineering, Construction and Architectural Management*, Vol. 23 No. 2, pp. 158-176.

Severijn, M.N. (2021), "A road map for successful implementation and adoption of applications in an industrial environment", M.Sc. in Operations Management and Logistics Master's thesis, Eindhoven University of Technology.

Shahruddin, S. and Zairul, M. (2020), "BIM requirements across a construction project lifecycle: a PRISMA compliant systematic review and meta-analysis", *International Journal of Innovation, Creativity and Change*, Vol. 12 No. 5, pp. 569-590.

Soester, M. (2021), "Top 15 reasons why project management migrations fail", available at: www.senseiprojectsolutions.com.au/ (accessed 26 August 2023).

Son, H., Lee, S. and Kim, C. (2015), "What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architects' behavioral intentions", *Automation in Construction*, Vol. 49, pp. 92-99.

Son, H., Park, Y., Kim, C. and Chou, J.S. (2012), "Toward an understanding of construction professionals' acceptance of mobile computing devices in South Korea: an extension of the technology acceptance model", *Automation in Construction*, Vol. 28, pp. 82-90.

Sorce, J. and Issa, R.R.A. (2021), "Extended technology acceptance model (TAM) for adoption of information and communications technology (ICT) in the US construction industry", *Journal of Information Technology in Construction*, Vol. 26, pp. 227-248.

Taylor, S. and Todd, P.A. (1995), "Understanding information technology usage: a test of competing models", *Information Systems Research*, Vol. 6 No. 2, pp. 144-176.

Teizer, J., Cheng, T. and Fang, Y. (2013), "Location tracking and data visualization technology to advance construction ironworkers' education and training in safety and productivity", *Automation in Construction*, Vol. 35, pp. 53-68.

Teo, H.H., Wei, K.K. and Benbasat, I. (2003), "Predicting intention to adopt interorganizational linkages: an institutional perspective", *MIS Quarterly*, Vol. 27 No. 1, pp. 19-49.

Teo, T.S.H., Lin, S. and Lai, K.H. (2009), "Adopters and non-adopters of e-procurement in Singapore: an empirical study", *Omega*, Vol. 37 No. 5, pp. 972-987.

Ting, T.L. and Yahaya, I. (2024), "Adoption of technology for construction site safety management: unveiling insight from Penang contractors", *Planning Malaysia*, Vol. 22 No. 3, pp. 31-46.

Tornatzky, L.G. and Klein, K.J. (1982), "Innovation characteristics and innovation adoption-implementation: a meta-analysis of findings", *IEEE Transactions on Engineering Management*, Vol. EM-29 No. 1, pp. 28-45.

Tornatzky, L.G., Fleischer, M. and Chakrabarti, A.K. (1990), *Processes of Technological Innovation*, Lexington Books, Lexington, MA.

Venkatesh, V. and Bala, H. (2008), “Technology acceptance model 3 and a research agenda on interventions”, *Decision Sciences*, Vol. 39 No. 2, pp. 273-315.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003), “User acceptance of information technology: toward a unified view”, *MIS Quarterly*, Vol. 27 No. 3, pp. 425-478.

Vigneshwar, R.V.K., Shanmugapriya, S. and Vaardini, U.S. (2022), “Analyzing the driving factors of BIM adoption based on the perception of the practitioners in Indian construction projects”, *Iranian Journal of Science and Technology, Transactions of Civil Engineering*, Vol. 46 No. 3, pp. 2637-2648.

Wang, G., Lu, H., Hu, W., Gao, X. and Pishdad-Bozorgi, P. (2020a), “Understanding behavioral logic of information and communication technology adoption in small-and medium-sized construction enterprises: empirical study from China”, *Journal of Management in Engineering*, Vol. 36 No. 6, pp. 1-11.

Wang, G., Wang, P., Cao, D. and Luo, X. (2020b), “Predicting behavioural resistance to BIM implementation in construction projects: an empirical study integrating technology acceptance model and equity theory”, *Journal of Civil Engineering and Management*, Vol. 26 No. 7, pp. 651-665.

Wang, M., Wang, C.C., Sepasgozar, S. and Zlatanova, S. (2020c), “A systematic review of digital technology adoption in off-site construction: current status and future direction towards industry 4.0”, *Buildings*, Vol. 10 No. 11, pp. 1-29.

Wang, X., Liu, L., Liu, J. and Huang, X. (2022), “Understanding the determinants of blockchain technology adoption in the construction industry”, *Buildings*, Vol. 12 No. 10, p. 1709.

Wuni, I.Y. and Shen, G.Q. (2020), “Barriers to the adoption of modular integrated construction: systematic review and meta-analysis, integrated conceptual framework, and strategies”, *Journal of Cleaner Production*, Vol. 249, pp. 1-17.

Xu, H., Feng, J. and Li, S. (2014), “Users-orientated evaluation of building information model in the Chinese construction industry”, *Automation in Construction*, Vol. 39, pp. 32-46.

Xue, H., Zhang, S., Wu, Z. and Zhang, L. (2023a), “How to improve the smart construction technology usage behavior of construction enterprise employees? — TOE framework based on configuration study”, *Engineering, Construction and Architectural Management*, ahead-of-print.

Xue, X., Sun, X., Xue, W., Wang, Y. and Liao, L. (2023b), “Investigating building information modeling acceptance in the Chinese AECO industry”, *Engineering, Construction and Architectural Management*, Vol. 30 No. 9, pp. 4253-4270.

Yap, J.B.H., Lee, K.P.H., Skitmore, M., Lew, Y.L., Lee, W.P. and Lester, D. (2023), “Predictors to increase safety technology adoption in construction: an exploratory factor analysis for Malaysia”, *Journal of Civil Engineering and Management*, Vol. 29 No. 2, pp. 157-170.

You, Z. and Feng, L. (2020), “Integration of industry 4.0 related technologies in construction industry: a framework of cyber-physical system”, *IEEE Access*, Vol. 8, pp. 122908-122922.

Yousafzai, S.Y., Foxall, G.R. and Pallister, J.G. (2007a), “Technology acceptance: a meta-analysis of the TAM: part 1”, *Journal of Modelling in Management*, Vol. 2 No. 3, pp. 251-280.

Yousafzai, S.Y., Foxall, G.R. and Pallister, J.G. (2007b), “Technology acceptance: a meta-analysis of the TAM: part 2”, *Journal of Modelling in Management*, Vol. 2 No. 3, pp. 281-304.

Yuan, H., Yang, Y. and Xue, X. (2019), “Promoting owners’ BIM adoption behaviors to achieve sustainable project management”, *Sustainability*, Vol. 11 No. 14, pp. 1-18.

Zaltman, G., Duncan, R. and Holbek, J. (1973), *Innovations and Organizations*, John Wiley and Sons, New York, NY.

Zhang, N., Guo, X. and Chen, G. (2008), “IDT-TAM integrated model for IT adoption”, *Tsinghua Science and Technology*, Vol. 13 No. 3, pp. 306-311.

Zhang, J., Zhang, M., Ballesteros-Pérez, P. and Philbin, S.P. (2023a), "A new perspective to evaluate the antecedent path of adoption of digital technologies in major projects of construction industry: a case study in China", *Developments in the Built Environment*, Vol. 14, pp. 1-16.

Zhang, W., Li, J. and Liang, Z. (2023b), "Barriers to building information modeling from an individual perspective in the Chinese construction industry: an extended unified theory of acceptance and use of technology", *Buildings*, Vol. 13 No. 7, pp. 1-17.

Zhao, Y., Sun, Y., Zhou, Q., Cui, C. and Liu, Y. (2023), "How a/E/C professionals accept BIM technologies in China: a technology acceptance model perspective", *Engineering, Construction and Architectural Management*, Vol. 30 No. 10, pp. 4569-4589.

Zhong, B., Wu, H., Li, H., Sepasgozar, S., Luo, H. and He, L. (2019), "A scientometric analysis and critical review of construction related ontology research", *Automation in Construction*, Vol. 101, pp. 17-31.

Zhou, Z., Su, Y., Zheng, Z. and Wang, Y. (2023a), "Analysis of the drivers of highway construction companies adopting smart construction technology", *Sustainability*, Vol. 15 No. 1, p. 703.

Zhou, Z.C., Su, Y.K., Zheng, Z.Z. and Wang, Y.L. (2023b), "Analysis of factors of willingness to adopt intelligent construction technology in highway construction enterprises", *Scientific Reports*, Vol. 13 No. 1, pp. 1-18.

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