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Beyond barriers: Stage-based and pathway-oriented conceptual model of resistance to BIM innovation

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ABSTRACT

Building Information Modeling (BIM) is regarded as a representative of digital innovation in the construction industry. However, the process of its innovation is often hindered by the resistance from stakeholders. Many studies view such resistance as a barrier or static outcome, overlooking both stage and pathway perspectives. Even when considered, existing discussions remain fragmented. To fill this gap, this paper integrates diffusion of innovation theory (DOI) and stimulus–organism–response (SOR) theory to build a theoretical framework that guides a systematic literature review of 55 journal articles. Based on the results, this study proposes a stage-based and pathway-oriented conceptual model to enhance the understanding of BIM innovation resistance. The conceptual model provides an intermediate theory, providing a theoretical basis for future knowledge development. It also offers stage-based practical references for managers and policymakers to identify and mitigate resistance in the process of BIM promotion.

1. Introduction

The architecture, engineering, and construction (AEC) industry is undergoing a rapid, digitally driven transformation [1]. As a key representative of digital innovation [2,3], Building Information Modeling (BIM) aims to enhance overall project performance by improving stakeholder collaboration and enabling real-time information exchange [4]. In response, many governments have introduced policies to promote BIM in the AEC sector and accelerate digital transformation [5,6].

The emergence of new construction methods, such as prefabrication and net-zero buildings, is rapidly increasing project complexity, coordination demands, and requirements for data accuracy, creating an urgent need for more efficient digital information management and interdisciplinary integration [7,8]. Although BIM is theoretically positioned as a key solution to these challenges and supported by policy, stakeholders have expressed skepticism and resistance toward its innovation in practice [1]. For example, in the UK, despite over a decade of government-led BIM promotion, its adoption still falls short of policy expectations [5], with stakeholder resistance identified as a key contributor to this gap [9,10]. This issue is not unique to the UK. Evidence from developing countries such as China [11–13], India [14], and Brazil [15], as well as developed economies including Canada [16], Australia [17], and New Zealand [18], consistently reveals widespread and persistent resistance to BIM innovation. This resistance undermines the potential of BIM and slows digital innovation across the construction industry [7,19–21].

Although resistance is frequently mentioned in BIM-related studies [22,23], it is often discussed alongside barriers, such as poor technological compatibility and the lack of standards [24,25]. It is also commonly described as a static outcome, such as stakeholders' reluctance to change existing workflows or resistance to change [24,25]. From this perspective, the process and formation pathway of BIM innovation resistance is overlooked. Specifically, stakeholder resistance to BIM is not a static outcome, but spans the entire stages of BIM innovation, ranging from pre-decision to decision-making and post-decision [26,27]. Stakeholders' attitudes and behaviors toward BIM evolve across these stages rather than remaining fixed at a single point in time [12,28,29]. For example, studies show that in the pre-decision stage, stakeholders often believe traditional methods meet their needs

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and react to BIM's uncertainty with fear and resistance [13,20,26]. During the decision stage, resource constraints and anticipated implementation risks frequently cause hesitation and wavering in stakeholders' intention to adopt BIM [30,31]. In the post-decision stage, challenges such as learning burdens, collaboration barriers, and unclear responsibilities may trigger resistance from stakeholders or lead to discontinued use [12,29,32].

Moreover, BIM innovation resistance is not equivalent to financial or technical barriers. Rather, it is a form of behavioral response arising from the interaction between external factors and human factors [33–35]. More specifically, external factors, such as technological complexity, change pressure, and resource constraints, need to be subjectively interpreted and cognitively processed by humans before they are perceived as having negative consequences [34–36]. Those perceptions may then trigger diverse behavioral responses, such as avoidance, resistance, or even abandonment [12,29].

Although some studies have identified the pathways of resistance at certain stages [14,20,21,37,38], this evidence remains fragmented and lacks systematic integration within a unified theoretical framework. This limitation arises from overlooking two key issues. First, the innovation resistance is both processual and stage-specific [39]. BIM, as an innovation, encounters resistance at multiple stages of its diffusion [28,31,40]. Second, resistance is essentially a behavioral response [35]. It emerges as an adverse reaction shaped by human subjective judgment in response to external factors [34,35]. Snyder [41] and Roberts et al. [42] state that reviewing and synthesizing existing literature provides opportunities to identify research gaps and advance theoretical development. To address these research gaps, this study aims to: (1) integrate diffusion of innovation theory (DOI) with the stimulus–organism–response (SOR) theory to construct a stage-based and pathway-oriented theoretical framework for reviewing BIM innovation resistance; and (2) conduct a systematic literature review to identify and organize the fragmented evidence in existing studies. Based on the proposed theoretical framework, this study synthesizes the evidence into a conceptual model that further develops the knowledge base. The proposed conceptual model supports further academic research and strengthens practical application. For researchers, it offers a solid foundation that serves as a stepping stone and theoretical basis for future empirical investigations. For industry managers and policymakers, the model can be translated into stage-specific guidelines to identify and mitigate potential resistance during the diffusion of BIM in practice.

To achieve the above objectives, the review is conducted as follows: Section 1 introduces the research background and goals. Section 2 reviews and defines the relevant theories and concepts of BIM innovation resistance, and constructs a theoretical framework based on DOI and SOR. Section 3 presents the research methodology, followed by the bibliometric analysis in Section 4. Section 5 presents the results of the literature review, structured around the pre-decision, decision, and post-decision stages, and compares their characteristics. Section 6 discusses the theoretical contributions and practical implications based on the conceptual model. Section 7 concludes the paper.

2. Theoretical background

This section develops the theoretical foundations and analytical framework of BIM innovation resistance. First, Section 2.1 reviews the definition of resistance and its main manifestations to clarify the basic concepts of this study. Second, Section 2.2 defines the scope of BIM innovation resistance in this study and introduces relevant theories to establish the analytical perspective. Finally, Section 2.3 integrates the theoretical framework based on the preceding discussion to support subsequent research.

2.1. Definition and manifestations of resistance

Resistance is widely defined as a multidimensional phenomenon that can cause delays, increased costs, and instability during organizational change [43]. In the context of information system innovation, resistance typically refers to the psychological discomfort and opposition response of stakeholders triggered by perceived external disadvantages during the adoption and implementation of new technologies [44–46].

Kim and Kankanhalli [45] define resistance as a stakeholder's negative cognitive and emotional reaction to IT-related change, especially when the change is perceived to increase the unfair workload of individuals or teams [46]. Klaus and Blanton [47] further note that resistance goes beyond verbal opposition and may include behavioral expressions such as delays, obstruction, or non-cooperation. Lapointe and Rivard [48] categorize resistance into public opposition, disruptive actions, non-adoption, inertia, and procrastination, emphasizing that these behaviors evolve across different stages of innovation implementation. Ferneley and Sobreperez [49] further subdivided resistance into rejection and non-adoption, highlighting that stakeholders may develop new forms of resistance even after initially agreeing to adopt a technology, such as non-use or passive avoidance, based on continuous assessment in subsequent practice.

2.2. Theoretical foundations of BIM innovation resistance

This section builds on the two main characteristics of BIM innovation resistance, which are the multi-stage process and the pathways of resistance formation, and introduces the Diffusion of Innovation (DOI) theory and the Stimulus–Organism–Response (SOR) theory to establish the analytical perspective.

2.2.1. BIM innovation resistance

Building Information Modeling (BIM) is not only a technical tool, but is widely regarded as an innovation that drives digital transformation in the construction industry [50]. The innovative nature of BIM lies not only in its technical features, such as 3D modeling and information integration, but also in its progressive reshaping of traditional workflows, organizational processes, and collaboration methods in construction [2,6,50]. Compared to traditional CAD tools, BIM requires real-time information sharing and multi-party collaboration, breaking the conventional linear workflow model [51,52]. Therefore, BIM innovation represents not just a technological upgrade, but a comprehensive transformation of processes, roles, and collaboration methods [2,50]. As a result, the challenges of BIM innovation extend beyond simple technology acceptance, encompassing a multi-stage process shaped by external constraints, cognitive complexity, and diverse stakeholder behaviors [23,37,53].

This study defines BIM innovation resistance as stakeholders' behavioral responses during its diffusion process, triggered by perceived adverse impacts associated with BIM-related external factors. Unlike traditional views that frame resistance as a barrier or static outcome [24,25], this study conceptualizes BIM innovation resistance as a dynamic, multi-stage behavioral response shaped by external and human factors. This study builds a theoretical framework to systematically review the literature on BIM innovation resistance. The framework integrates two dimensions, stages of BIM innovation diffusion and formation paths of resistance, drawing respectively on the DOI and SOR.

2.2.2. A stage-based perspective on innovation resistance

This study applies the Diffusion of Innovation (DOI) theory to understand the process of BIM innovation and the manifestation of resistance that occurs at different stages. According to Rogers' Diffusion of Innovation theory [54] and its subsequent extensions [3,55], the innovation process consists of three stages: the pre-decision stage (knowledge and persuasion), the decision stage, and the post-decision stage (implementation and confirmation). Resistance to innovation occurs throughout all stages and typically takes two primary forms, passive resistance and active resistance [39,56]. The following sections describe the specific manifestations of resistance at each stage.

In the knowledge stage, stakeholders encounter the innovation for the first time [39,57]. Due to an inherent aversion to change, they often exhibit an instinctive avoidance of novelty itself [58]. At this stage, resistance is not directed at the innovation itself (e.g., product or technology), but at the instinctive reaction to the change it implies [39,56,59,60]. External factors disturb humans' psychological comfort zones and threaten the status quo, triggering initial resistance, which is classified as passive resistance [57,59]. Passive resistance is typically not based on rational evaluation but driven by personality traits (e.g., openness, risk aversion) and cognitive biases (e.g., status quo bias, loss aversion), leading to intuitive rejection or neglect of the innovation [39,56].

As cognitive processing deepens, individuals enter the persuasion stage [61], where they begin to evaluate the attributes of the innovation, such as relative advantage, complexity, compatibility, and perceived risks [61]. When these evaluations are unfavorable, individuals may develop negative attitudes and behavioral tendencies toward the innovation [54]. Resistance that arises from such subjective evaluation is referred to as active resistance [39,62]. Unlike passive resistance, active resistance stems largely from perceived innovation barriers, such as excessive complexity, unclear value, incompatibility with existing processes, or significant transition costs [39]. Once these barriers are perceived to exceed a certain threshold of tolerance, adopters tend to form negative attitudes toward the innovation [63]. Notably, even this seemingly rational resistance is not entirely based on objective evaluation. Individual traits and cognitive biases may continue to shape the evaluation process, amplifying the perceived intensity of innovation barriers [39].

In the decision stage, stakeholders may initially express a positive intention to adopt [39]. However, if they later reassess the innovation's usability, value alignment, or feasibility and perceive shortcomings, their attitudes may shift. This can result in contradictory decisions, including rejection or non-adoption [62].

In the post-decision stage (implementation and confirmation), if the actual user experience falls short of expectations or the innovation fails to deliver its promised benefits, users may discontinue use, manifesting as adoption discontinuance or voluntary abandonment [64]. In other words, resistance may continue to evolve even after implementation, ultimately affecting the depth of technology use and its long-term adoption [49].

2.2.3. A pathway-oriented perspective on innovation resistance

This study applies the Stimulus–Organism–Response (SOR) theory to understand the pathway of BIM innovation resistance. Proposed by Mehrabian and Russell [65], the theory emphasizes that behavioral responses are not triggered directly by external stimuli, but are mediated through human internal psychological processing, which leads to either approach or avoidance behaviors [33–35]. In the context of BIM innovation resistance, the three core components of the SOR can be mapped as external factors, human factors, and manifestations of resistance.

First, stimulus from external factors refers to the preconditions for resisting BIM, representing the objective factors that give rise to innovation resistance [39]. These factors include: (1) the changes introduced by the innovation, which disturb the current status quo [39,59]; and (2) barriers, which refer broadly to constraints that hinder or prevent the adoption and implementation of innovation [66–68]. External factors can be categorized into three levels: (1) Industry level, which refers to the broader environment in which the innovation is embedded, including market acceptance, client demand, social norms, and regulatory constraints [67,68]. These factors shape the institutional legitimacy and diffusion environment of the innovation [66]. (2) Organizational level, which involves factors such as available resources, structure, culture, managerial support, and leaders' risk preferences [30,50]. These factors determine whether the innovation can be effectively adopted and promoted within the organization [50]. (3) Project level, which reflects the practical process of innovation implementation, involving team capabilities, task workflows, and the division of responsibilities [50,68].

The organism can be concretely understood as the mediating role of human factors, specifically how individuals perceive and process external factors [33,34,65]. Human factors encompass three key dimensions: (1) Personality traits [12,29,69]. An individual's natural disposition toward change significantly influences their acceptance of innovation [39]. For example, resistance to change and personal innovativeness represent two opposing characteristics [12,69]. Oreg [69] identified dimensions of resistance to change, including routine seeking, cognitive rigidity, emotional sensitivity, and short-term focus. These traits reduce the likelihood of accepting new information and engaging in novel behaviors [39]. In contrast, personal innovativeness reflects the willingness and ability to adopt new technologies proactively and serves as a key driver of technology acceptance [29]. (2) Cognitive biases [39,56,59]. Individuals often exhibit irrational behavioral tendencies due to cognitive biases that affect their judgment and decision-making [45]. Status quo bias is common in innovation resistance, referring to the tendency to maintain current conditions even when better alternatives exist [39,56,59]. This bias may stem from emotional attachment to existing tools and identity associations [70], as well as sunk cost effects and loss aversion related to potential failure [70,71]. (3) Perception [28]. Individuals' perceptions of an innovation directly influence their willingness to adopt and their behavioral decisions [28]. Perception plays a critical role in several classical theoretical models [28], including prospect theory, status quo preference theory, equity theory, transaction cost theory, as well as the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) [21,71–73]. Common perceptions of an innovation include perceived usefulness, perceived ease of use, perceived resource availability, perceived risk, perceived transition costs (e.g., monetary cost and non-monetary cost), perceived distributive equity, and subjective norms [21,28,72–74].

The response refers to resistance behaviors that emerge after external factors are processed through the human mind [33,34]. These responses primarily occur on two levels: (1) Attitudinal responses, such as negative perceptions, distrust, or avoidance toward BIM [12,20]. (2) Behavioral responses, including delayed adoption, rejection of use, or continued reliance on traditional methods [21,40].

2.3. Theoretical framework of BIM innovation resistance

Building on the analyses in Sections 2.1 and 2.2, this study integrates DOI [39,54] and SOR [65] to develop a theoretical framework of BIM innovation resistance (Fig. 1), aimed at systematically reviewing the existing body of literature. From a stage-based perspective, resistance to BIM innovation spans the entire diffusion process, including the pre-decision stage (knowledge and persuasion), the decision stage, and the post-decision stage (implementation and confirmation) [39]. From a pathway-oriented perspective, resistance is triggered by external factors and mediated by human factors [33,34]. The external factors include changes and barriers at the industry, organizational, and project levels [39,66,67]. The human factors include personality traits, cognitive biases, and perceptions [28,39,45,69]. The resistance manifests primarily in attitudinal and behavioral forms [12,20,21,40], involving both passive and active resistance [39,56,59]. Based on this framework, the study categorizes and scopes existing research on BIM innovation resistance to identify stage-based resistance factors and their formation pathways.

3. Methodology of the literature review

To systematically review the literature on the resistance to BIM innovation, this study adopts a systematic literature review (SLR). This method is widely used in theory development and evidence synthesis due to its structured, transparent, and replicable nature [53,75]. Guided by a pre-established theoretical framework, the study follows a clear set

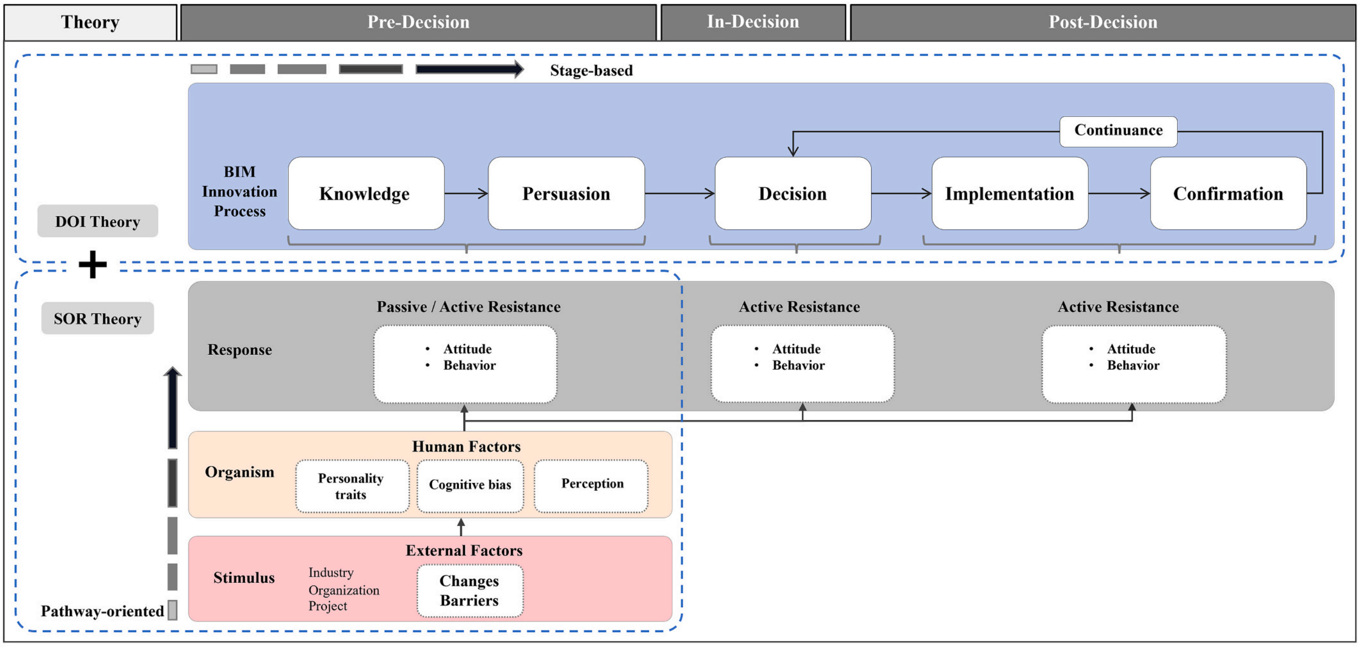

Fig. 1. Theoretical framework of BIM innovation resistance.

of procedures and criteria, from literature retrieval and screening to analysis, to ensure the comprehensiveness and consistency of the review process. A two-stage qualitative content analysis was conducted to code and categorize textual data, providing a solid foundation for the subsequent analysis [51,76], as illustrated in Fig. 2.

3.1. Search criteria

The sample was collected from the Scopus and Web of Science (WoS) databases. These platforms cover a wide range of high-impact journals, offer strong complementarity, and are widely used in bibliometric studies [75,77]. In addition, both databases serve as key sources of BIM-related research, and many influential reviews in this field have used them for data extraction [3,53,77].

To identify relevant evidence and discussions on resistance to BIM innovation, this study developed a keyword-based search strategy. The keywords cover three dimensions: (1) BIM-related terms, (2) resistance-related terms, and (3) terms related to external factors and human factors. To avoid missing potentially relevant literature due to overly strict logic, this study applied the OR operator between external and human factors instead of the AND operator. Based on this strategy, this study constructed a Boolean search formula (Table 1) and applied it separately in Scopus and WoS for initial screening. Finally, this study retrieved 88 articles from Scopus and 363 articles from Web of Science.

3.2. Literature selection and inclusion criteria

When defining inclusion and exclusion criteria, this study did not impose any publication date restrictions and included all available years. This study included only peer-reviewed journal articles written in English. It excluded grey literature such as conference papers, book chapters, and short reports, which typically lack analytical depth and may introduce unnecessary research bias [78]. This study also excluded review articles, as the goal was not to synthesize existing reviews, in line with the recommendations of Oraee et al. [79]. In addition, the study excluded publications from unrelated disciplines such as biology, water resource management, and oncology.

During the screening process, this study first excluded articles focused on technical details or specific applications of BIM based on their titles and abstracts. In the subsequent full-text review, this study excluded publications that lacked full-text access or did not explicitly mention the factors or pathways related to resistance. For example, studies that list resistance merely as a barrier without further analysis were not included [24,25]. In total, this study included 55 articles that met the inclusion criteria for further analysis.

3.3. Analysis and coding

According to Miles and Huberman [80], systematic analysis of qualitative data is typically conducted through coding. This practical approach toward extracting meaning from any type of qualitative data, including published studies, leads to deeper insight and makes marking and sorting of qualitative data doable at a greater speed, with more flexibility and accuracy [51,81]. This study conducted the content analysis in two stages.

The first stage involved identifying relevant text. The research team examined paragraphs from the included studies to detect statements related to resistance to BIM innovation, including its associated factors and its pathways, and coded them accordingly. Following Saldana's [76] guidelines on in vivo coding, the team copied these raw statements word for word into a spreadsheet.

The second stage involved assigning meanings to statements in the spreadsheet by categorizing them, namely, coding each statement using descriptive codes [51,76]. Following Bazeley's [81] recommended approach, this study interpreted the identified factors using the priori codes to ensure interpretive consistency during the second stage. The list of a priori codes included the three stages proposed in this study's theoretical framework, along with three categories of resistance factors and their corresponding subcategories (see Fig. 1).

Once all research team members reached consensus on the selected codes, each article's focal areas were assigned one or more corresponding codes. The team discussed coding issues during regular online meetings. In cases of disagreement, the team continued discussions until consensus was achieved. The coding process began by assigning the selected content from each article to the pre-decision, decision, and post-decision stages as defined in the theoretical framework. Then, the content was further categorized into external factors (industry, organization, project), human factors (personality traits, cognitive bias,

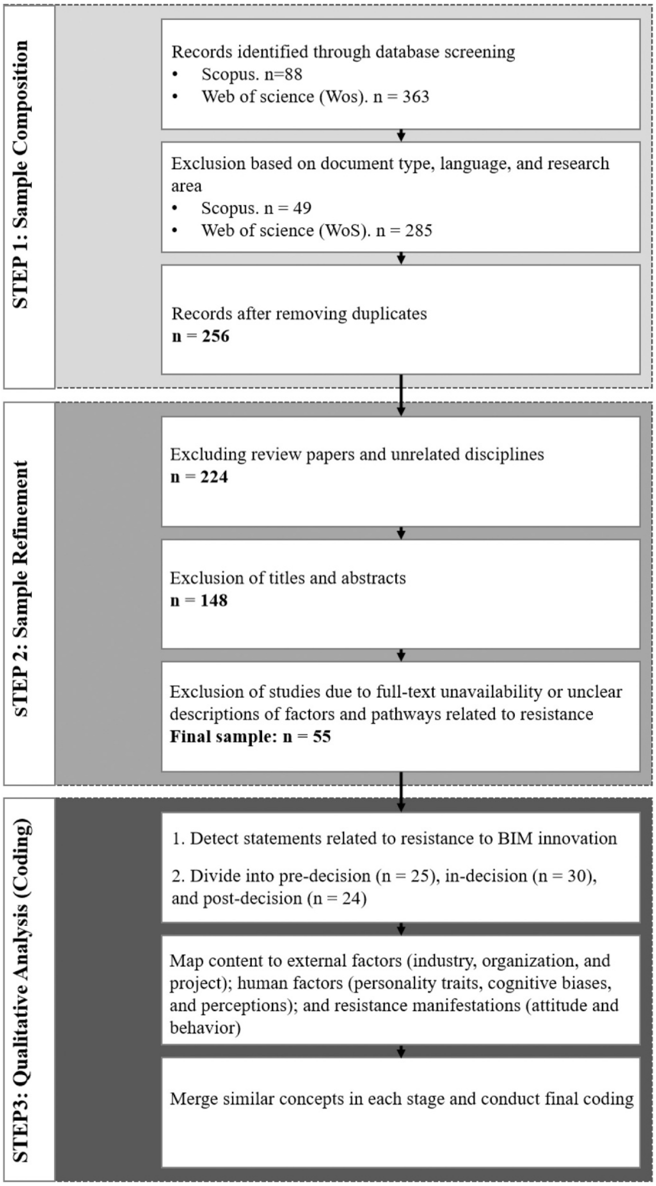

Fig. 2. Literature review approach (by the author).

Table 1
Search strings.

Keyword Category	Search Strings
BIM Terms	"BIM" OR "building information model*" OR "building information modeling"
Resistance Terms	"resist*" OR "reluctance" OR "refusal" OR "avoidance" OR "negative attitude*" OR "delay" OR "inertia" OR "abandon*" OR "non adopt*" OR "hesitant*" OR "resistance to change" OR "unwillingness"
External Factor and Human Factor	"change*" OR "barrier*" OR "challenge*" OR "constraint*" OR "hindrance*" OR "impediment*" OR "implementation difficult*" OR "perceived usefulness" OR "perceived ease of use" OR "subjective norm*" OR "perceived behavioral control" OR "perceived resource availability" OR "perceived risk" OR "transition cost*" OR "sunk cost*" OR "loss aversion" OR "risk aversion" OR "status quo bias" OR "threat" OR "loss of control" OR "loss of autonomy" OR "emotional complexity" OR "frustration" OR "distrust" OR "fear"

Note: The wildcard "*" is used to capture plural forms, thereby improving the comprehensiveness of the search.

perception), and resistance manifestations (attitude, behavior). After completing this stage, the research team analyzed the grouped factors within each stage and category and merged conceptually similar descriptions. Finally, the identified factors were coded. Specifically, PRD denotes "pre-decision," IND denotes "in-decision," and POD denotes "post-decision." E refers to external factors (I: industry, O: organization, P: project), H to human factors (T: personality traits, C: cognitive bias, P: perception), and R to resistance (A: attitude, B: behavior). For example, PRD-*E*-I1 refers to the first subcategory under industry-level external factors in the pre-decision stage.

This study ultimately conducted coding analysis on 55 included articles. The results showed that 25 of them involved the pre-decision stage, 30 involved the decision stage, and 24 involved the post-decision stage, with 19 studies covering two or more stages. The identified factors for each stage include: in the pre-decision stage, 7 external factors, 6 human factors, and 4 resistance manifestations; in the decision stage, 14 external factors, 11 human factors, and 2 resistance manifestations; and in the post-decision stage, 10 external factors, 6 human factors, and 4 resistance manifestations. The complete coding results are presented in Appendix A.

4. Overview of the literature on BIM innovation resistance

This section provides an overview of the distribution of studies on BIM innovation resistance (Fig. 3 and Table 2). Specifically, it first reviews the temporal evolution of the literature (Fig. 3) and then summarizes the main publication sources (Table 2). The following subsections discuss these aspects.

4.1. Publication timeline

Fig. 3 illustrates the annual number of publications on this topic. Since 2017, the number of studies related to resistance to BIM innovation has shown a stepwise upward trend, with publications from 2017 to 2023 accounting for 62 % of the total sample. This trend partly reflects the growing recognition that the primary challenges in BIM innovation arise not only from technical limitations, but also from stakeholder behavior and the social structure of the construction industry [23,51,53]. As a result, an increasing number of studies have focused on stakeholder attitudes and behaviors in BIM adoption and implementation, leading to a gradual rise in literature that contains evidence on resistance to BIM innovation.

4.2. Publication sources

Table 2 presents the distribution of publications across different sources. Journals that have published at least four articles include Engineering, Construction and Architectural Management, Automation in Construction, and Architectural Engineering and Design Management. Engineering, Construction, and Architectural Management and Automation in Construction together contributed 14 articles (26 % of the sample), highlighting their leading academic role in research on BIM innovation acceptance, adoption, and implementation.

5. Results from the review on BIM innovation resistance

Guided by the proposed theoretical framework, this study coded and categorized 55 journal articles to systematically examine the external factors, human factors, resistance manifestations, and formation pathways of resistance to BIM innovation across the pre-decision, decision, and post-decision stages. In coding the qualitative data, including published studies, the frequency of coded items is treated as an indicator of their relative importance within the dataset [81]. Items with higher frequency are considered to hold greater explanatory value [81]. The following sections present the resistance factors and pathway of BIM innovation resistance across different stages, based on their frequency of

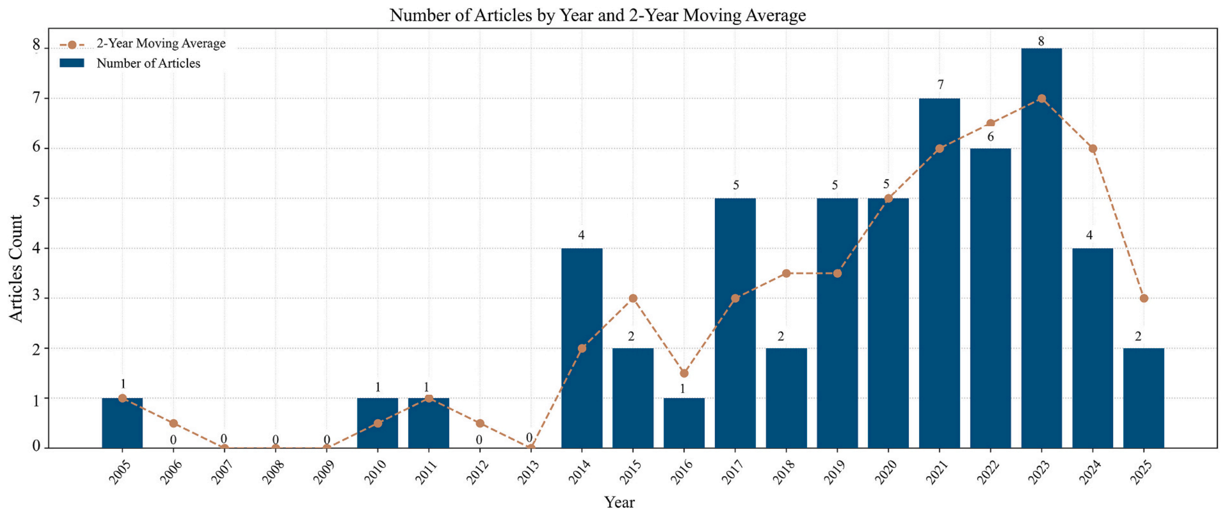

Fig. 3. Number of all publications.

Table 2
Distribution of publications among different sources.

Publication Sources	Number of Publications
Engineering, Construction, and Architectural Management	8
Automation in Construction	6
Architectural Engineering and Design Management	4
Journal of Management in Engineering	3
Buildings	3
Construction Management and Economics	3
Journal of Construction Engineering and Management	2
Journal of Information Technology in Construction	2
Journal of Civil Engineering and Management	2
Construction Innovation	2
International Journal of Project Management	2
Proceedings of the ICE – Municipal Engineer	1
CivilEng	1
Built Environment Project and Asset Management	1
Ain Shams Engineering Journal	1
Journal of Engineering, Design and Technology	1
Building and Environment	1
Advances in Civil Engineering	1
Energy and Buildings	1
Journal of Cleaner Production	1
Computers in Industry	1
Infrastructures	1
International Journal of Sustainable Construction Engineering and Technology	1
Kybernetes	1
Frontiers of Engineering Management	1
Journal of Building Engineering	1
Journal of Systems and Management Sciences	1
Visualization in Engineering	1

occurrence (f) in the literature.

5.1. *Resistance in the pre-decision stage*

Fig. 4, based on the analysis in Appendix A, shows the distribution of coded data related to the pre-decision stage. Among external factors, the most frequently discussed topic was the changes in working methods or processes (PRD-*E*-P2, f = 14), followed by the transition from traditional drawing tools (PRD-E-P3, f = 9) and lack of understanding of BIM benefits (PRD-E-O1, f = 9). For human factors, status quo bias (PRD-H-C1) appeared most frequently (f = 17), followed by emotional response-fear or threat (PRD-H-T2, f = 7) and low perceived usefulness (PRD-H-P1, f = 4). In terms of resistance manifestations, unwillingness to change (tools, processes, roles) (PRD-R-A1) was the most frequently cited (f = 13), followed by continued use of traditional CAD methods (PRD-R-B1, f = 4) and distrust or skepticism toward BIM (PRD-R-A2, f = 3). These results outline the key characteristics of resistance during the pre-decision stage.

In addition, Fig. 4 further explains the pathway of resistance during this stage. In the knowledge stage, stakeholders come into contact with BIM either actively or passively, become aware of its existence, and acquire initial information about it [3,6]. Upon exposure to the stimulus of BIM innovation, stakeholders exhibit an initial response [55]. This stage may trigger the first signs of resistance [39,56]. The resistance does not target BIM itself but rather the fundamental changes it introduces [13,26,37]. The intensity of resistance depends on both the stakeholder's inherent tendency to resist change and their satisfaction with the current state [39,60]. Stakeholders who strongly resist change and express high satisfaction with current practices are more likely to form negative reactions before conducting any in-depth evaluation [60]. For instance, some stakeholders have used CAD tools for an extended period, become accustomed to current workflows, and firmly believe these methods fully meet their needs [26,37,38,82,83]. In such cases, changes in working methods, processes, and tools introduced by BIM may be perceived as disruptions to the status quo, triggering fear or a sense of threat and leading to resistance [13,84,85]. Moreover, this early tendency toward resistance appears to be closely linked to personality traits [39]. Prior studies have shown that older professionals are more likely than younger ones to reject the changes introduced by BIM [13,26,86]. Professionals with a rigid mindset also struggle to accept new ways of working [83]. Such psychological defense mechanisms may cause stakeholders to selectively ignore information related to BIM [40], thereby disrupting the knowledge acquisition process and preventing progression into the persuasion stage.

When stakeholders show conscious interest in BIM, they enter the persuasion stage [61]. In forming their attitudes, stakeholders actively seek out related information and evaluate aspects such as its technical functions, adoption and implementation costs, and application potential in projects [87]. This evaluation is often shaped by individual experience, specific needs, and the surrounding organizational context [3]. For example, if stakeholders lack a basic understanding of BIM's core concepts or advantages, they may instinctively underestimate its value, perceive it as unnecessary, and adopt a rejecting attitude [40,88,89]. Stakeholders may also view BIM as overly complex, requiring significant time and effort to learn and implement, which adds to their workload and triggers negative emotions [14]. Structural inertia at the industry and organizational levels can also hinder individuals from deepening their understanding of BIM [13,90–92]. Even when individuals are

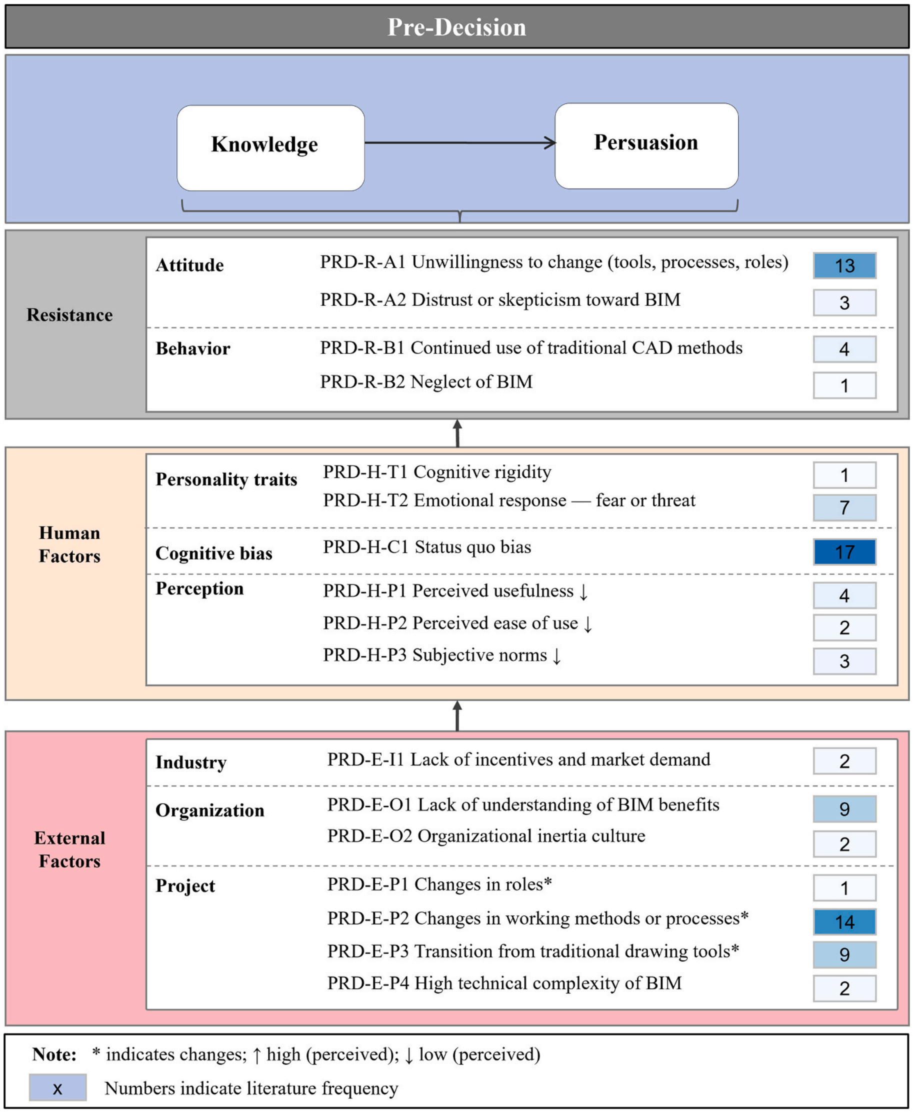

Fig. 4. BIM innovation resistance in the pre-decision stage (by the author).

willing to adopt BIM, prevailing social norms often make it difficult for them to deviate from established practices [47,91,93]. In addition, personal traits and cognitive biases continue to influence stakeholders' judgments during the evaluation process [39,56]. For instance, some project managers may perceive BIM as a threat to their authority or status within the team, leading to fear and emotional resistance [94]. Architects may resist BIM due to the sunk cost effect, being reluctant to abandon resources already invested in traditional tools and workflows [20].

5.2. Resistance in the in-decision stage

Fig. 5, based on the analysis in Appendix A, presents the coding distribution of the literature related to the decision stage. Among external factors, high initial investment cost (IND-*E*-O1) was the most frequently cited (f = 20), followed by uncertainty about return on investment (IND-E-O2, f = 13) and legal and contractual liability risks (IND-E-P5, f = 10). Among human factors, perceived risk (IND-H-P5) emerged as the most prominent issue (f = 19), followed by perceived transition cost (IND-H-P3, f = 14) and subjective norms (IND-H-P6, f = 11). Regarding manifestations of resistance, hesitation, wait-and-see, and unwillingness (IND-R-A1) appeared most frequently in the literature (f = 17), followed by refusal, non-adoption, and non-implementation (IND-R-B1, f = 11). These high-frequency factors outline the key characteristics of resistance during the decision stage.

In addition, Fig. 5 also indicates the formation path of resistance during the decision stage. In the decision stage, stakeholders build on their initial attitudes to evaluate the alignment between BIM and their upcoming workflows, ultimately determining whether to adopt the innovation [3,55]. This stage typically involves assessing the feasibility of BIM implementation, including its potential benefits, technical compatibility, market demand, anticipated implementation challenges, and internal resource allocation [3]. If decision-makers perceive the innovation as lacking usability or failing to meet expected practical needs, resistance is likely to arise. In that case, their attitudes may shift, resulting in decisions that contradict the earlier positive expectations formed during the persuasion stage [62].

First, high initial investment costs, including software acquisition, staff training, and process restructuring, combined with uncertain short-term returns, lead managers to perceive high risk and high transition costs [26,28,30,95]. As a result, stakeholders often hesitate when making BIM adoption or implementation decisions [26,68,88,95]. Especially when organizational resources are limited, organizational managers may be hesitant or unwilling to invest, or even refuse to adopt new technologies, due to the dual effects of perceived high risk and perceived limited resource availability [28,96,97]. In addition,

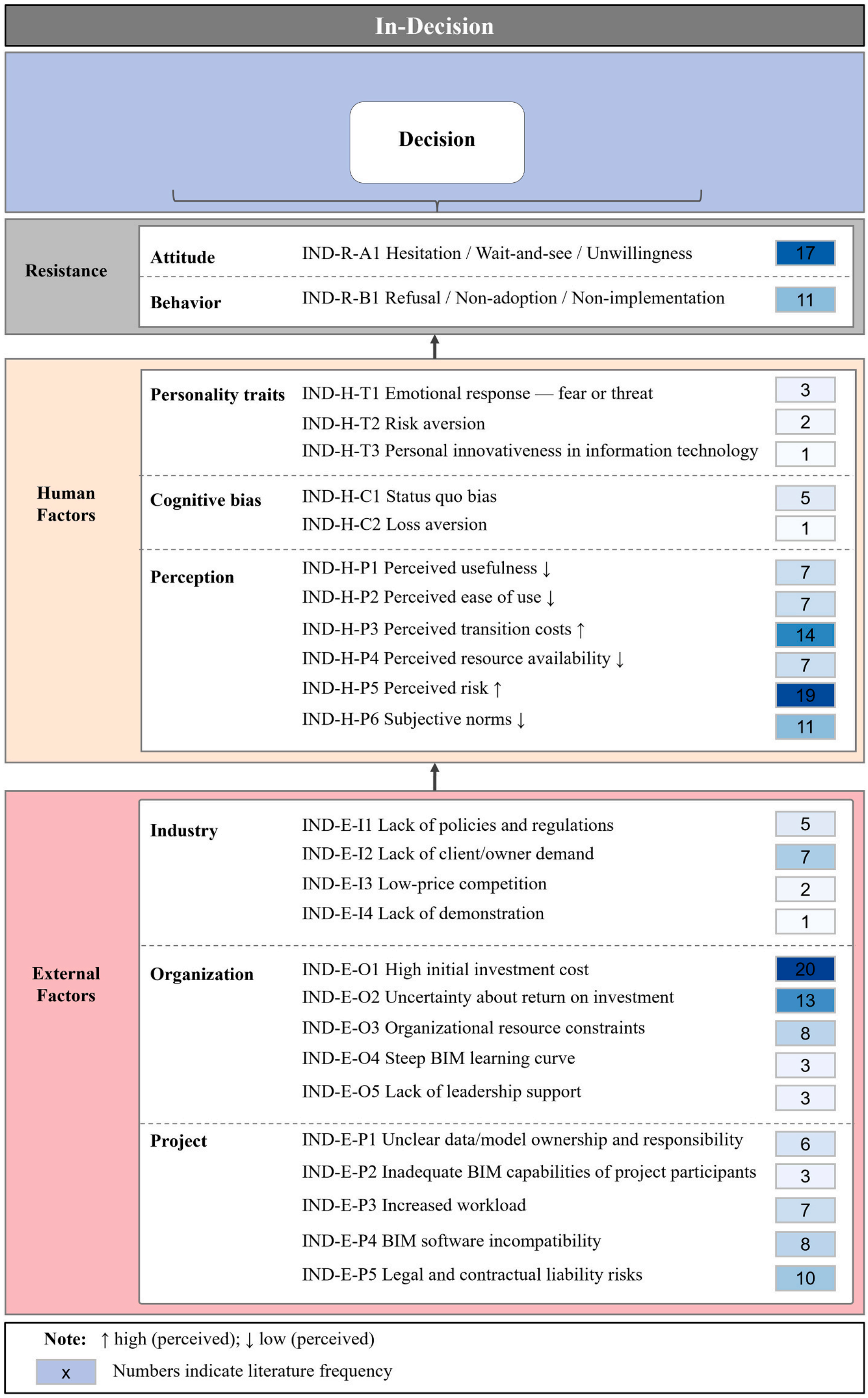

Fig. 5. BIM innovation resistance in the in-decision stage (by the author).

stakeholders often anticipate the potential challenges that may arise after BIM adoption during the decision-making process. When these barriers are expected to exceed their tolerance threshold, stakeholders may develop negative emotions or resistance behaviors [39]. For example, if stakeholders perceive the BIM system as too difficult to use and believe that the benefits are offset by the investment required, they may be unwilling to adopt the new technology [26,98]. Stakeholders also worry about implementation issues such as interoperability challenges, unclear responsibility and data ownership, and increased workloads. These uncertainties may lead to fear and ultimately refusal to adopt BIM [20,99–101]. Furthermore, when clients and project partners do not require BIM, stakeholders may perceive no compelling reason to adopt it [26,31,85,102,103]. As noted in the literature, even BIM-skilled professionals may choose not to embrace it, opting instead to follow prevailing industry demand [85,94].

In addition, decision-makers' personality traits and cognitive biases seem to play a critical role at this stage [12,28]. Stakeholders who are risk-averse or highly satisfied with existing processes tend to avoid the uncertainty associated with new technologies [39,45]. This mindset often causes organizational leaders to focus excessively on BIM's perceived drawbacks, such as steep learning curves, high training and implementation costs, and uncertainties linked to future technological changes [20,28,97]. As a result, they may view existing mature technologies as more reliable and prefer to maintain the status quo to avoid the risks associated with BIM-driven transformation [20,28]. As Oesterreich and Teuteberg state that senior managers in construction firms often abandon BIM investment due to loss aversion when confronted with high costs and uncertain returns [23].

5.3. Resistance in the post-decision stage

Fig. 6 presents the coding distribution of post-decision literature, based on the analysis results from Appendix A. Among external factors, increased workload in modeling and coordination (POD-*E*-P6, f = 11) is the most frequently cited source of resistance. Ambiguity in responsibility boundaries (POD-E-P3, f = 8) and inadequate BIM capabilities of project participants (POD-E-P1, f = 6) are also highlighted in several studies. Among human factors, perceived transition cost (POD-H-P4, f = 16) and perceived risk (POD-H-P5, f = 9) are dominant, followed by low perceived ease of use (POD-H-P3, f = 5). In terms of resistance manifestations, expressions of dissatisfaction or negative sentiment (POD-R-A1, f = 12) are most common, followed by passive use (POD-R-B1, f = 5) and postponement or delay in BIM use (POD-R-B2, f = 4).

In addition, Fig. 6 further presents the formation path of resistance during the post-decision stage. The implementation stage links behavioral components with intended outcomes, leading to actual behavior [39]. However, adoption intentions do not always translate into consistent behavior [54]. In other words, when stakeholders encounter stimuli that sharply contradict their prior expectations, they may revise their decisions and reject innovations they initially intended to adopt [64].

During implementation, unclear responsibilities between project teams and the absence of standardized contracts expose stakeholders to uncertainty and require them to invest additional effort to manage potential risks [17,68,104,105]. These risks and costs discourage stakeholders from sharing models or lead them to implement BIM merely for compliance rather than for meaningful use [40,105,106]. In addition to

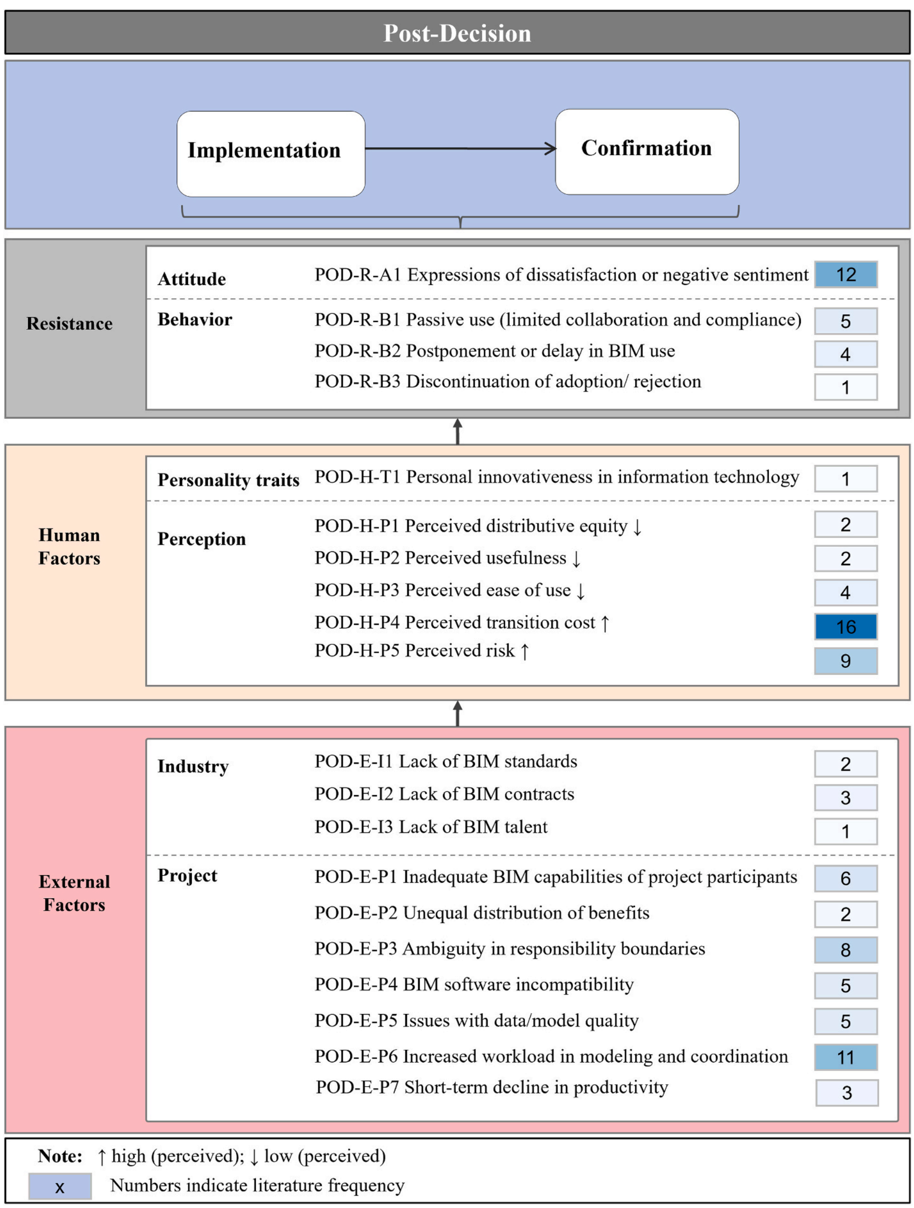

Fig. 6. BIM innovation resistance in the post-decision stage (by the author).

the increased workload associated with BIM modeling, stakeholders are also required to conduct extensive checking and validation tasks, which contributes to negative attitudes [37,52,68,107]. Compatibility issues between BIM software further exacerbate these challenges, making stakeholders experience the practical difficulties of BIM implementation [106,108]. Moreover, limited capabilities among project participants require stakeholders to engage in intensive communication and coordination for effective BIM collaboration [68,107,109]. The additional time, effort, and coordination difficulties trigger frustration and dissatisfaction, and in some cases, force stakeholders to revert to traditional CAD-based workflows [40,106,110]. As Wang et al. state, if stakeholders' additional efforts, such as increased workload and responsibility, are not adequately compensated, they may perceive the distribution of duties and benefits as unfair, which weakens their motivation and leads to minimal compliance with BIM implementation requirements [21].

In the confirmation stage, stakeholders encounter more BIM-related information and real-world experience [29,110]. At this stage, when new and contradictory stimuli challenge prior actions, stakeholders may discontinue adoption or actively reject BIM [21,29,108,110]. First-hand experience with the challenges of BIM implementation often leads stakeholders to reassess the sustainability of their initial decisions [110]. When BIM performance fails to meet initial expectations, dissatisfaction tends to intensify [29,108,110]. As reported in studies, disorganized workflows, increased workload, and unclear accountability in BIM projects often result in stakeholder exhaustion and frustration, reducing their willingness to replicate the process in future projects [98,110].

5.4. Stage- and pathway-based characteristics of BIM innovation resistance

Based on Sections 5.1–5.3, this section summarizes the characteristics of resistance factors and pathways at different stages.

In terms of resistance factors, industry- and project-level external factors span the pre-decision, decision, and post-decision stages. Organizational factors are concentrated mainly in the first two stages. Among human factors, personality traits and perceptions occur in all three stages but manifest differently. Emotional responses shift from an instinctive fear of new technology in the pre-decision stage to concerns over high investment and legal or contractual risks in later stages [26,85,99,101]. Regarding perception factors, perceived usefulness, ease of use, switching costs, and risks evolve from early anticipated assessments to later experience-based reassessments [12,29,100]. Subjective norms shift from internal cultural pressure within the organization to a lack of support from clients, partners, and industry mainstream in later stages [13,30,111]. Preference for the status quo develops from instinctive avoidance of unknown changes to a conservative stance driven by potential loss [20,26,30]. The manifestations of resistance also differ across stages. Attitudes evolve from emotional rejection [13,85], to rational hesitation [31,112], to dissatisfaction driven by unmet expectations [98,109].

Regarding resistance pathways, pre-decision resistance may not be directed at BIM technology itself but may instead reflect an instinctive reaction to changes in work practices [31,113]. Limited understanding appears to foster a closed attitude among stakeholders, blocking the possibility of attitude change [40,85]. In the decision stage, resistance may arise from stakeholders' trade-offs among costs, risks, and benefits [28,95]. When expected benefits are perceived as insufficient to outweigh the required investments and associated risks, even stakeholders who initially held positive views may delay or reject BIM adoption [28,30,31]. In the post-decision stage, resistance tends to be shaped by implementation experiences that do not align with prior expectations, which may prevent initial intentions from translating into sustained use [29,98,100].

6. Discussion of conceptual model

Based on the previous qualitative analysis of BIM innovation resistance literature and the proposed theoretical framework, this study developed a conceptual model, as shown in Fig. 7.

6.1. Contribution to theory and knowledge

The conceptual model developed in this study makes two key theoretical contributions. First, this study validates Talke and Heidenreich's [39] work on innovation resistance, which categorizes resistance into distinct stages of innovation and highlights the critical role of the innovation process in understanding resistance. This observation is essential for understanding digital innovation resistance in the construction context. Second, this study makes a specific contribution to the knowledge base on BIM innovation resistance. Compared with existing literature on BIM innovation resistance, the proposed conceptual model advances the relevant body of knowledge. It extends the work of Andersson and Eidenskog [37], who argued that resistance to BIM should be examined not only from the perspective of barriers, but also through an integrated lens of technology, organization, and practice to generate new insights. In addition, this framework is the first to apply the SOR to address the limitation of relying solely on the DOI framework in BIM research, which often neglects the behavioral pathways of stakeholders [2,3,53]. It also extends the SOR by integrating a process perspective to overcome its limitations in explaining the stage-by-stage evolution of stakeholder resistance [33,34,114]. Finally, although the barrier perspective dominates discussions on BIM resistance [22–25], this study calls for incorporating stage-based and pathway-oriented dimensions into the analysis of BIM innovation resistance.

Furthermore, by systematically reviewing BIM innovation resistance, this study makes a significant contribution to understanding how and where such resistance occurs. Previous studies in this field have discussed the resistance in BIM innovation processes in a fragmented manner [21,28,37,115], indicating a clear need for an overarching analytical framework that integrates all relevant factors and pathways leading to such resistance. In addition, the model enhances awareness of the interconnections and mutual influences between external and human factors in BIM innovation resistance. It places particular emphasis on human factors, which are considered a critical aspect of the current research [23,98]. Essentially, the conceptual model integrates multiple theoretical perspectives and provides a theoretical foundation for future empirical investigations into BIM innovation resistance and broader digital innovation resistance in the construction industry. The model offers a needed consensus framework for research on digital transformation in construction, representing the principal theoretical contribution expected of a conceptual model [51].

6.2. Propositions for managers and policymakers

The stage-based and pathway-oriented conceptual model proposed in this study offers managers and policymakers an actionable framework. Unlike static barrier lists, the model reveals the dynamic characteristics of resistance across pre-decision, decision, and post-decision stages, and offers a simple tool to translate this knowledge into checklists or guidelines for managing BIM innovation resistance. For example, the managerial implications and practical insights are organized into three main propositions:

- Prioritize external conditions at industry, organizational, and project levels

External factors initiate the resistance chain and create the conditions for resistance to arise. At the industry level, knowledge dissemination and external incentives could foster an innovation-friendly environment. For example, establishing BIM demonstration projects,

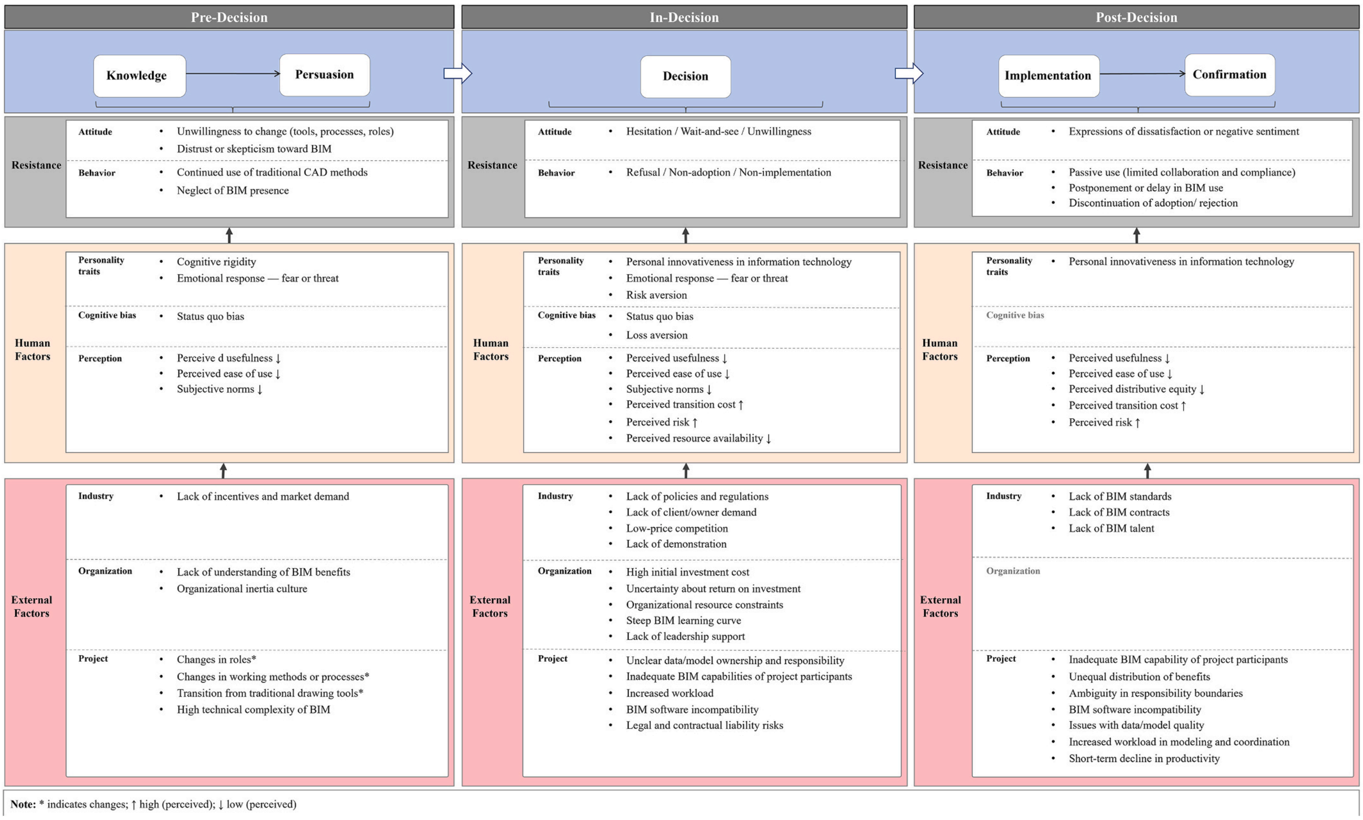

Fig. 7. BIM innovation resistance conceptual model.

open case repositories, and knowledge portals tends to lower learning barriers and support intuitive understanding [116,117]. Building and establishing collaborative platforms between industry, universities, and government may facilitate experience sharing, improving access to BIM knowledge [118–120]. At the organizational level, pilot projects and case-based learning could support the gradual accumulation of practical experience [68,112]. In addition, a phased investment approach grounded in cost-benefit analysis may alleviate the stress of one-time capital expenditure and improve financial control [23,112]. At the project level, detailed BIM implementation plans and collaboration guidelines, clarifying stakeholder roles, data delivery milestones, and information-sharing rules, appear to reduce coordination costs [119,121,122].

- Consider human factors rather than relying solely on technical or process optimization

Personality traits, cognitive biases, and perception factors play a critical mediating role between external conditions and actual resistance behaviors [34,39]. Liu et al. [109] and Oraee et al. [51] suggest that soft interventions may play a meaningful role in this process. For instance, fostering a positive and open innovation culture may help mitigate knowledge inertia. Showcasing successful BIM applications is reported to potentially rebuild stakeholder confidence and willingness to engage [122,123]. Targeted training and certification programs may help ease anxiety caused by knowledge gaps and enhance adaptability [52,124].

- Consider stage-specific response approaches.

The causes of resistance appear to differ across stages. In the pre-decision stage, resistance may stem from limited awareness of BIM's value, preference for the status quo, and instinctive fear of change. Prior studies suggest that promotional activities, demonstrations, and peer exchanges may help lower stakeholders' psychological barriers [20,23,90]. During the decision stage, cost–benefit analysis and risk expectations could be the main triggers. Transparent return-on-investment analyses, pilot projects, and risk-sharing mechanisms could help to reduce hesitation and delay [23,112]. In the post-decision stage, additional workload, unclear responsibility boundaries, and unmet expectations may contribute to resistance. Ongoing leadership support, clear contractual frameworks, and performance feedback may help sustain active participation [107,109,125].

7. Conclusion

This study constructs a theoretical framework for BIM innovation resistance from stage-based and pathway-oriented perspectives. Based on this framework, a systematic literature review was conducted to examine studies related to resistance in the BIM innovation process. A comprehensive conceptual model of BIM innovation resistance was developed accordingly. The model divides the process horizontally into three stages: pre-decision, decision, and post-decision. Vertically, it outlines the resistance pathways at each stage, including external factors, human factors, and resistance manifestations.

First, based on DOI and SOR theory, this paper proposes a theoretical framework that identifies and classifies the formation paths of BIM innovation resistance across three stages, contributing to theory development. This addresses gaps in prior research, which has often lacked stage-specific analysis and clear explanations of how resistance develops. In addition, the proposed conceptual model overcomes the limitations of fragmented and static interpretations of BIM innovation resistance in existing research. It offers a theoretical foundation and analytical context for future research. Second, in terms of practical implications, this study provides an analytical tool that construction managers and policymakers may refer to. The staged and pathway features of resistance in the model can help managers and policymakers with a rationale for designing strategies to promote BIM and broader digital transformation.

Although this study proposes an insightful theoretical framework and a comprehensive literature synthesis, several limitations must be acknowledged. First, the model is conceptually derived from existing literature and has not yet been empirically validated. Second, limitations in the scope and method of literature inclusion, along with the inevitable subjectivity of coding, may lead to missing key variables or overestimating certain factors. Therefore, applying this model requires contextual consideration and cautious interpretation. These limitations also open new avenues for future research. For instance, future studies can conduct field investigations, surveys, or case studies to empirically validate the model and test the causal relationships among variables. Further analysis could investigate different resistance factors in greater depth, to explore their evolution mechanisms and interaction patterns. In addition, the model's applicability across countries, regions, and cultural settings remains to be further examined. Future studies could conduct comparative empirical research across diverse contexts.

In conclusion, this paper provides a preliminary theoretical framework and research foundation for understanding BIM innovation resistance from both theoretical and practical perspectives, aiming to support future research efforts and promote the broader transformation of BIM and other digital innovations in the construction industry.

CRediT authorship contribution statement

Yuanyuan Tan: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Hanbing Wang:** Writing – original draft, Methodology, Formal analysis, Data curation. **Ruopeng Huang:** Writing – review & editing, Formal analysis. **Daniel Hall:** Writing – review & editing, Methodology, Formal analysis. **Ad Straub:** Writing – review & editing, Supervision, Methodology. **Queena K. Qian:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. BIM innovation resistance coding results

Stage	Categories	Level	Code	Sub-categories	Reference
Pre-Decision	External Factors	Industry	PRD-E-I1	Lack of incentives and market demand	[14,83]
		Organization	PRD-E-O1	Lack of understanding of BIM benefits	[14,19,27,40,85,88,89,94,113]
			PRD-E-O2	Organizational inertia culture	[13,27]
		Project	PRD-E-P1	Changes in roles*	[94]
			PRD-E-P2	Changes in working methods or processes*	[13,20,31,37,38,83–85,88,103,104,126]
			PRD-E-P3	Transition from traditional drawing tools*	[11,20,26,68,82,84,88,103,126]
			PRD-E-P4	High technical complexity of BIM	[14,26]
	Human Factors	Personality traits	PRD-H-T1	Cognitive rigidity	[83]
			PRD-H-T2	Emotional response - fear or threat	[13,20,26,84,85,94,110]
		Cognitive bias	PRD-H-C1	Status quo bias	[11,19,20,26,27,31,37,38,82,84–86,103,104,110,113,126]
		Perception	PRD-H-P1	Perceived usefulness ↓	[11,14,40,89]
			PRD-H-P2	Perceived ease of use ↓	[14,126]
			PRD-H-P3	Subjective norms ↓	[13,14,83]
	Resistance Manifestation	Attitude	PRD-R-A1	Unwillingness to change (tools, processes, roles)	[11,19,20,26,31,38,84–86,89,104,110,126]
			PRD-R-A2	Distrust or skepticism toward BIM	[27,88,89]
		Behavior	PRD-R-B1	Continued use of traditional CAD methods	[14,26,82,83]
			PRD-R-B2	Neglect of BIM presence	[40]
In-decision	External Factors	Industry	IND-E-I1	Lack of policies and regulations	[26,31,96,113,127]
			IND-E-I2	Lack of client/owner demand	[19,31,83,85,98,103,128]
			IND-E-I3	Low-price competition	[26,128]
			IND-E-I4	Lack of demonstration	[30]
		Organization	IND-E-O1	High initial investment cost	[19,26,30,31,68,83,85,88,95–98,101,104,109,111,113,127,129,130]

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Stage	Categories	Level	Code	Sub-categories	Reference
			IND-E-O2	Uncertainty about return on investment	[20,28,30,31,68,83,88,100–102,104,112,127]
			IND-E-O3	Organizational resource constraints	[28,30,31,94,96,97,104,127]
			IND-E-O4	Steep BIM learning curve	[98,111,127]
			IND-E-O5	Lack of leadership support	[12,83,97]
		Project	IND-E-P1	Unclear data/model ownership and responsibility	[95,96,99,101,109,130]
			IND-E-P2	Inadequate BIM capabilities of project participants	[98,103,104]
			IND-E-P3	Increased workload	[19,20,31,68,94,100,128]
			IND-E-P4	BIM software incompatibility	[20,26,83,94,95,98,101,130]
			IND-E-P5	Legal and contractual liability risks	[31,95,96,99,109,112,113,127,128,130]
	Human Factors	Personality traits	IND-H-T1	Emotional response-fear	[101,102,128]
			IND-H-T2	Risk aversion	[28,97]
			IND-H-T3	Personal innovativeness in information technology	[12]
		Cognitive bias	IND-H-C1	Status quo bias	[30,88,97,102,104]
			IND-H-C2	Loss aversion	[102]
		Perception	IND-H-P1	Perceived usefulness ↓	[26,30,101,104,112,127,128]
			IND-H-P2	Perceived ease of use ↓	[20,26,30,83,98,100,128]
			IND-H-P3	Perceived transition cost ↑	[19,31,68,83,88,95,96,98,102,104,109,113,127,130]
			IND-H-P4	Perceived resource availability ↓	[28,31,83,96,97,113,127]
			IND-H-P5	Perceived risk ↑	[19,20,28,30,31,68,83,88,95,96,99,100,102,104,112,113,127,128,130]
			IND-H-P6	Subjective norms ↓	[12,26,30,31,83,98,102,103,113,127,128]
	Resistance Manifestation	Attitude	IND-R-A1	Hesitation / wait-and-see / unwillingness	[12,20,28,30,31,68,83,85,95,96,99,109,112,127–130]
		Behavior	IND-R-B1	Refusal / non-adoption / non-implementation	[19,26,88,94,97,100–102,104,111,113]
Post-decision	External Factors	Industry	POD-E-I1	Lack of BIM standards	[26,37]
			POD-E-I2	Lack of BIM contracts	[68,94,104]
			POD-E-I3	Lack of BIM talent	[26]
		Project	POD-E-P1	Inadequate BIM capabilities of project participants	[17,29,40,94,106,131]
			POD-E-P2	Unequal distribution of benefits	[21,109]
			POD-E-P3	Ambiguity in responsibility boundaries	[21,37,104,105,109,112,131,132]
			POD-E-P4	BIM software incompatibility	[21,32,68,107,108]
			POD-E-P5	Issues with data/model quality	[26,52,68,105,133]
			POD-E-P6	Increased workload in modeling and coordination	[12,21,32,37,68,88,107–110,131]
			POD-E-P7	Short-term decline in productivity	[17,29,108]
	Human Factors	Personality traits	POD-H-T1	Personal innovativeness in information technology	[12]
		Perception	POD-H-P1	Perceived distributive equity ↓	[21,52]
			POD-H-P2	Perceived usefulness ↓	[29,108]
			POD-H-P3	Perceived ease of use ↓	[21,32,106,131]
			POD-H-P4	Perceived transition cost ↑	[12,17,21,26,32,37,68,88,94,105–110,131]
			POD-H-P5	Perceived risk ↑	[17,26,52,68,104,105,109,112,133]

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Stage	Categories	Level	Code	Sub-categories	Reference
	Resistance Manifestation	Attitude	POD-R-A1	Expressions of dissatisfaction or negative sentiment	[12,32,52,68,88,94,107–109,131–133]
		Behavior	POD-R-B1	Passive use (limited collaboration and compliance)	[21,26,82,104,112]
			POD-R-B2	Postponement or delay in BIM use	[17,40,106,112]
			POD-R-B3	Discontinuation adoption/ rejection	[29]

Note: * indicates changes; ↑ high (perceived); ↓ low (perceived).

Data availability

Data will be made available on request.

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