

Article

Predicting Behavioral Resistance to BIM Implementation Among Design Engineers in Construction Projects: An SQB-Based Empirical Study from China

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Abstract

The application of Building Information Modeling (BIM) in construction projects can significantly improve project efficiency, accuracy, and collaboration among stakeholders. However, construction professionals, particularly design engineers, exhibit behavioral resistance to BIM implementation, which has hindered the achievement of expected benefits. To explore the behavioral resistance to BIM implementation, this study integrates the status quo Bias (SQB) theory and the innovation diffusion theory and proposes a factor model for predicting the behavioral resistance of architectural engineering design engineers to BIM implementation. The model was empirically tested through partial least squares structural equation modeling (PLS-SEM) on survey data collected from design engineers in BIM-based construction projects in China. The results indicate the following: (1) resistance to change ($\beta = 0.383$), BIM compatibility, and BIM user satisfaction play prominent but independent roles in predicting behavioral resistance to BIM implementation, and (2) resistance to change is motivated by inertia ($\beta = 0.473$), self-efficacy, and perceived distributive equity. The proposed framework provides a more nuanced account of resistance to BIM implementation. Specifically, deep-seated cognitive biases and innovation-specific perceptions independently and jointly shape behavioral resistance, a distinction often overlooked in prior research. Practically, this research provides recommendations for effectively addressing resistance behaviors within construction project settings.

Keywords: building information modeling (BIM); behavioral resistance; theory of status quo bias; BIM adoption and diffusion



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1. Introduction

BIM is a representative application of technical innovation in the construction industry. Recent research, through exploring the driving forces behind the adoption of BIM in developing countries (e.g., Pakistan and Saudi Arabia [1,2]), has found that the use of BIM in construction projects can effectively reduce design changes, improve design quality, lower construction costs, and enhance the level of collaboration among all project stakeholders [3,4]. It serves as a significant potential approach to improving project performance [5]. However, despite having advanced technologies (such as using BIM-assisted wall-climbing robots for automated surface inspections [6]), and despite decades of development, the promotion and implementation of BIM have still fallen short of expectations [7]. Even

among companies that have already implemented BIM in construction projects, a significant portion has not achieved the expected benefits from its application [8]. One significant challenge impeding the effectiveness of BIM initiatives stems from the behavioral resistance exhibited by construction professionals, particularly design engineers [9]. This resistance manifests in various forms, such as a hesitance to embrace new processes, a strong inclination towards conventional tools like AutoCAD, or a passive resistance to change, all of which impede the smooth and efficient integration of BIM practices. As a result, this resistance not only diminishes the potential gains from investing in BIM technology but also hampers the pace of digital transformation within construction organizations. Therefore, it is imperative to address and overcome this resistance to fully capitalize on the advantages offered by BIM implementation.

Rogers pointed out that, under authoritative innovation decision-making processes, individuals within an organization exhibit significant behavioral differences in their adoption of innovations [10]. Resistance is a common behavior and is also considered a major reason for the failure of many information system implementations [11]. In construction projects, the adoption of BIM is based on authoritative innovation decisions, where leaders (such as owners, project managers, or team leaders) decide whether to implement BIM. Construction industry professionals adopt BIM driven by internal efficiency needs and external isomorphic pressures [12]. The resistance behaviors they exhibit can hinder the implementation of BIM and reduce the effectiveness of its use. Therefore, resistance to changes associated with the adoption of BIM constitutes a particularly significant factor contributing to the unforeseen outcomes in BIM implementation performance.

The predominant portion of existing research on BIM has concentrated chiefly on the adoption and dissemination of BIM, which occurs at three distinct levels: organizational-level BIM diffusion [13,14], project-level BIM diffusion [15,16], and individual-level BIM diffusion [17]. To date, this body of empirical research has predominantly concentrated on elucidating the willingness and behaviors associated with the implementation of BIM across various levels. Scholars have investigated the impact of technical, organizational, and individual determinants on the motivations and behaviors of construction professionals throughout various stages of BIM implementation, encompassing the pre-adoption, adoption, and post-adoption phases [18–21]. However, user resistance as a complex phenomenon, scholars indicated that resistance should not be equivalent to non-adoption [22]. This implies that research on resistance requires the development of an entirely new theoretical paradigm for in-depth exploration, rather than simply borrowing from the adoption research framework. Moreover, research has highlighted that resistance is a common phenomenon in the promotion of BIM and serves as a significant barrier to its widespread adoption [23].

Research on behavioral resistance toward BIM implementation is still in its infancy. Zhang et al. constructed an empirical model from the perspective of psychological capital, integrating the theory of planned behavior, their study explored the adoption behavior of design engineers towards BIM, emphasizing that enhancing the positive psychological states of designers and strengthening their psychological capital are of great significance for the promotion and application of BIM [24]. This study has filled a research gap in the exploration of resistance to BIM implementation. However, BIM use leads to a redistribution of work content, processes, and authority within organizations. BIM implementation behavior is not merely the result of construction professionals' pursuit of pure technical innovation or the quest for optimal economic benefits. Research following the post-adoption phase has emphasized the extensive changes in the interactions between BIM and organizational environments, culture, social structures, and power dynamics. It should not be simply regarded as the promotion and use of an information system, but rather analyzed

in terms of the complex social issues [25]. Therefore, explaining behavioral resistance to BIM implementation solely from the perspective of psychological capital remains insufficient, and the definition of BIM usage behavior in existing research is still relatively vague. To address this, Wang et al. conducted an in-depth study on the mechanisms influencing resistance behavior during the post-adoption phase of BIM by integrating the Technology Acceptance Model and Equity Theory [26]. The findings of the study suggest that post-adoption behavioral resistance to BIM implementation among construction professionals is influenced by an integrated assessment encompassing both the technical advantages—specifically, the perceived ease of use and perceived usefulness of BIM technology—and the organizational change dimension, notably the perceived distributive equity associated with BIM implementation. This research offers a relatively thorough elucidation of the mechanisms underlying behavioral resistance to the implementation of BIM. However, perceived ease of use is primarily used to reflect users' objective evaluation, either during the pre-implementation or implementation phase [27]. Furthermore, existing studies have confirmed that individual behavior is not solely the result of rational choice but can also be triggered by emotional changes caused by stress [28]. Therefore, a more comprehensive theoretical perspective is needed to fully explain behavioral resistance to BIM implementation.

The existing literature on BIM has extensively examined its adoption and diffusion at organizational, project, and individual levels. Grounded in theoretical frameworks such as the Technology Acceptance Model (TAM), a substantial body of research has focused on identifying the facilitators and intentions underlying BIM adoption. Furthermore, post-adoption studies have begun to explore the continued usage of BIM and the complex socio-technical adjustments, including changes in workflows and power dynamics, that follow its implementation. However, a notable gap remains in understanding the critical implementation phase, where BIM is being rolled out and integrated, and traditional work methods (e.g., based on AutoCAD) coexist with, and are gradually replaced by, new BIM-based workflows. In this AutoCAD-BIM transition context, behavioral resistance is not merely a rational calculation of technology utility or post-implementation fairness. Instead, it frequently manifests as an instinctive response to disruption, which can be effectively explained by Status Quo Bias. Status quo bias refers to the widespread inclination to favor the existing state. This bias manifests as resistance to change, whereby individuals exhibit a tendency to favor familiar routines, such as AutoCAD-based workflows, over the perceived uncertainty associated with adopting new approaches, like BIM [24]. The psychological basis for design engineers' resistance during this transition period, even when mandated to adopt BIM, remains underexplored.

To bridge the gaps, we have constructed a model to predict the design engineers' behavioral resistance to BIM implementation. In particular, our research objectives are as follows: (1) to identify the contextual antecedents of resistance to change toward BIM in the AutoCAD-BIM transition context, and (2) to examine how resistance to change influences behavioral resistance to BIM implementation. Drawing on status quo bias theory, we identify three categories of factors associated with resistance to change: cognitive misconception, psychological commitment, and rational decision making. Inertia, self-efficacy, and perceived distribution equality are contextual manifestation of cognitive misconception, psychological commitment, and rational decision making, respectively. We also build on innovation diffusion theory and propose the effects of resistance to change on design engineers' behavioral resistance to BIM through the underlying BIM compatibility, and BIM user satisfaction. The proposed model was empirically evaluated using data collected from design engineers employed in Chinese construction firms. This research contributes to the broader understanding of SQB by extending its explanatory scope and

provides valuable insights into the behavioral resistance encountered during BIM adoption in construction projects.

2. Literature Review and Hypothesis Development

2.1. Literature Review

2.1.1. Behavioral Resistance to BIM Implementation

The existing research has suggested that behavioral resistance should not be equated with “non-use” or “non-adoption” [29]. Resistance can occur at any stage of information system adoption, including the pre-adoption, adoption, and post-adoption phases. Nonetheless, it is essential to clarify the fundamental causes of resistance behaviors across various stages. While previous studies on BIM resistance have identified the stages at which resistance occurs [26], they have not provided a clear definition of the resistance concept itself. To address this gap, this study draws on the definition of resistance proposed by Lapointe [30] and defines BIM resistance during the adoption phase across five dimensions: initial conditions, resistance subjects, resistance objects, perceived threats, and resistance behaviors, as shown in Table 1. (1) Initial Conditions: Despite the diffusion of BIM, traditional work methods, such as the AutoCAD-based workflow, have not disappeared and are still in use. Construction professionals inevitably experience a transition from traditional work models to BIM-based workflows. Consequently, the coexistence of traditional work methods and BIM-based workflows is the most prominent characteristic of the adoption phase. (2) Resistance Subjects: This study defines the subject of BIM resistance at the individual level, specifically referring to construction professionals in the field who are expected to adopt BIM. (3) Resistance Objects: The adoption of BIM technology can face various forms of resistance within organizations. Resistance often targets not only the BIM software itself (e.g., issues with interoperability) but also the organizational changes induced by BIM implementation, such as the need for workflow restructuring and changes in job responsibilities. (4) Perceived Threats: Existing research suggests that users do not resist all changes brought about by information systems, but rather react with resistance to changes perceived to negatively impact their own interests [31]. Resistance can be attributed to people-oriented, system-oriented, or interaction factors, as outlined in Markus’s resistance attribution perspectives [31]. During the BIM implementation phase, perceived threats may include human factors (e.g., personal emotions, cognitive factors), technical factors (aspects of the BIM technology), and human-technology interaction factors (organizational changes triggered by BIM). (5) Resistance Behaviors: Research on information system resistance shows that users display various resistance behaviors, such as passive resistance, aggression, or deliberate sabotage [31]. Although BIM is often adopted through top-down decision making, project participants retain the freedom to choose how they use the technology. Resistance behaviors should not hinder the fulfillment of construction professionals’ main responsibilities. Engaging in actions like attacking or deliberately sabotaging BIM implementation will inevitably lead to negative consequences for the professionals involved. Thus, this study defines behavioral resistance to BIM implementation as primarily passive, encompassing actions like complaining and non-cooperation. Resistance plays a crucial role in the implementation of adopted innovations, appearing in various forms, including cognitive, affective, and behavioral dimensions. Among these, behavioral resistance is often seen as the most critical and is defined in innovation management and information systems literature as actions that oppose changes associated with the introduction of innovations, such as information systems. Consequently, this study concentrates on behavioral resistance.

Table 1. Definition of Behavioral Resistance to BIM Implementation.

Term	Behavioral Resistance to BIM Implementation
Initial Conditions	The coexistence of traditional work methods and BIM-based workflows.
Resistance Subjects	Construction professionals in the industry who use BIM technology.
Resistance Objects	BIM technology itself, and the changes induced by BIM (e.g., shifts in task distribution, authority, and workflow).
Perceived Threats	Human factors (emotions and cognition of BIM users, such as a preference for traditional work methods or doubts about their own abilities), technical factors (whether BIM can improve work efficiency and quality), and interactional factors (organizational changes brought about by BIM).
Resistance Behaviors	Non-compliance, lack of cooperation, disagreement, and opposition to changes or transformations introduced by the BIM implementation.

2.1.2. Status Quo Bias

The status quo bias (SQB) provides a theoretical foundation for understanding how past behaviors or choices influence current decision-making processes. The theory posits that users' preference for the status quo can be explained through three dimensions: rational decision making, cognitive misperception, and psychological commitment [32]. Rational decision making indicates that users, before deciding whether to adopt a new information system, will assess the trade-off between the benefits and costs of switching from incumbent systems to new alternatives. If the perceived costs outweigh the benefits, this leads to a preference for maintaining the status quo. Users predominantly assess two categories of costs: transition costs and uncertainty costs. Transition costs refer to the expenditures associated with the implementation of a new information system. This study primarily explains rational decision making from the perspective of net gains. Based on the definition of BIM resistance in Table 1, the organizational changes brought about by BIM are a significant factor leading to resistance among construction professionals. Perceived distributive equity serves as a key reflection of how construction professionals assess the net benefits of the organizational changes induced by BIM. Therefore, this study selects perceived distributive equity to explain the rational decision-making dimension of BIM resistance. Cognitive misperception manifests in users' tendency to exaggerate potential losses due to loss aversion, potentially biasing them against adopting new information systems. As seen in Table 1, during the adoption phase of BIM, the coexistence of traditional work methods and BIM-based workflows is a crucial factor, as professionals exhibit inertia due to loss aversion towards the experience and skills accumulated in existing practices. This psychological commitment is influenced by three key factors: sunk costs, social norms, and self-control. Sunk costs refer to the time, skills, and experience invested in the existing information system, which construction professionals consider when transitioning to a new system. Social norms, or the behavioral standards within the work environment, also influence users' actions. Self-control, or the extent to which users exert effort to maintain the status quo or embrace change, is a crucial determinant of psychological commitment. This study examines the role of self-efficacy, representing the self-control dimension, in shaping professionals' psychological commitment during the adoption of BIM.

Following Zhang et al. [24], this study selects resistance to change as the external manifestation of status quo bias. The resistance to change in the adoption of new information systems can be characterized by four key dimensions: routine seeking, emotional reaction, short-term focus, and cognitive rigidity [24]. Routine seeking reflects the extent to which users prefer the existing system environment. Emotional reaction captures the psychological stress experienced by users when confronted with change. Short-term focus

indicates a preoccupation with the immediate benefits of the current system. Cognitive rigidity denotes the reluctance of users to modify their perceptions and opinions about the new system [33]. The most direct impact of status quo bias is its weakening effect on users' willingness to adopt the new information system [11]. Transitioning to a new system often requires partially or completely replacing the existing one, leading users to resist the change. Furthermore, status quo bias manifests as a biased evaluation of the changes introduced by the new system [11]. Specifically, it results in a diminished assessment of the opportunities presented by the new system while amplifying the perceived threats associated with its implementation. These two bias effects contribute to a greater perception of losses than gains during the transition, thereby reducing users' inclination to adopt the new system.

2.2. Research Model and Hypotheses Development

To study the behavioral resistance of design engineers to the adoption of BIM, we propose an integrated prediction model based on SQB and innovation diffusion theory (see Figure 1). According to the definition of behavioral resistance to BIM Implementation (see Table 1), perceived threats to resistance encompass human, technical, and interactional factors. This implies that resistance behavior is determined by a combination of rational and psychological oriented cognitions. The SQB elucidates individuals' inherent psychological inclination to uphold existing conditions, rooted in inertia, aversion to loss, and familiarity with current work paradigms, elucidating the irrational reluctance towards change in resistance. However, the SQB theory does not comprehensively address how the specific attributes of innovations, such as BIM, interact with this psychological inertia. In contrast, the IDT systematically elucidates how innovation attributes like compatibility, complexity, and relative advantage influence adoption decisions, providing a rational evaluation based on innovation characteristics. By integrating SQB with the IDT, this study can concurrently capture both the internal psychological inertia (explained by SQB) and external cognitive barriers to innovation (explained by IDT) that contribute to behavioral resistance, thereby offering a more profound insight into how these two factors interact to create a resistance mechanism.

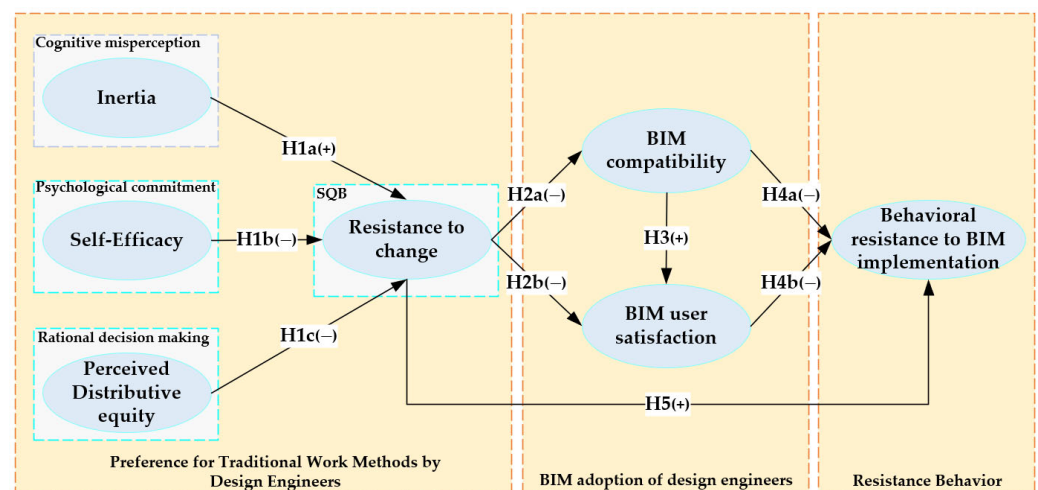


Figure 1. Research model.

2.2.1. The Impact of Inertia on Resistance to Change

Inertia represents a psychological tendency in which individuals are reluctant to modify their behaviors, preferring to maintain existing practices or states [32]. In information systems research, Polites et al. [34] argue that inertia reflects users' strong attachment to

the current system. Even when superior alternatives are available, users remain hesitant to alter their usage behaviors or intentions. The authors further delineate inertia into three dimensions for a more comprehensive understanding: emotional inertia, cognitive inertia, and behavioral inertia. Emotional inertia refers to users' attachment to the existing information system due to feelings of comfort and satisfaction. This emotional dependence leads users to persist with the current system. Cognitive inertia occurs when users recognize that the current system may not be optimal for their work, and that the new system offers clear advantages, yet they continue using the existing system. Behavioral inertia stems from the habits developed through prolonged use of the current information system, compelling users to maintain this usage pattern. Extant research has confirmed that during transitions from incumbent to new systems, users with high inertia exhibit stronger emotional, cognitive, and usage preferences for the existing system [35], display a greater tendency to resist the new system [36], and demonstrate lower willingness to adopt the new system [37]. Therefore, design engineers with a strong attachment to conventional work practices may exhibit psychological resistance to adopting BIM. This resistance may stem from a failure to recognize the advantages of BIM, such as reduced design changes and improved communication of design schemes, compared to traditional design methods. Based on these analyses, the following hypothesis is proposed:

H1a: *Design engineers' inertia toward traditional work methods is positively associated with their resistance to change toward BIM implementation.*

2.2.2. The Impact of Self-Efficacy on Resistance to Change

Self-efficacy, conceptualized as an individual's belief in their capacity to effectively perform a particular behavior or task, has been demonstrated to exert a substantial influence on how individuals respond to change. Existing research indicates that higher levels of self-efficacy are associated with greater confidence in completing tasks, as well as stronger control over uncertainties and challenges [38]. Within the framework of BIM implementation, self-efficacy plays a crucial role. The adoption of BIM requires project participants to not only learn new technologies but also adapt to the organizational changes it brings, such as new workflows and tasks. Design engineers with higher self-efficacy tend to exhibit greater confidence and control over these BIM-related transformations, leading to a reduced tendency to resist the changes [24]. Based on this, the following hypothesis is proposed:

H1b: *Design engineers' self-efficacy is negatively associated with their resistance to change toward BIM implementation.*

2.2.3. The Impact of Perceived Distributive Equity on Resistance to Change

The human–system interaction theory provides a robust theoretical framework for understanding information system resistance behavior and managing such resistance [31]. This theory suggests that reductions in perceived value or satisfaction caused by organizational changes can lead to resistance behaviors. This implies that individuals' rational evaluations of information systems consider not only the technical benefits but also the organizational changes introduced [31]. A sense of fairness is a critical means by which users evaluate the impact of organizational changes [39]. Existing literature has confirmed that a lack of perceived distributive equity can directly lead to resistance behaviors toward BIM implementation [26]. If the organization can reasonably compensate design engineers for their BIM-related work and fairly distribute the benefits generated by BIM, such as performance rewards and work commitments, the perceived distributive equity among

project team members will increase, thereby reducing their tendency to resist BIM-related changes. These arguments lead to the following hypothesis:

H1c: *Design engineers' perceived distributive equity is negatively associated with their resistance to change toward BIM implementation.*

2.2.4. The Impact of Status Quo Bias on BIM Implementation

The degree to which an innovation aligns with the prevailing value system, prior experiences, and requirements of prospective adopters constitutes a critical determinant affecting its diffusion [10]. However, research on the diffusion and application of BIM has largely overlooked this aspect. Shirowzhan et al. [40] emphasized the importance of understanding BIM compatibility from both organizational and technical perspectives. From an organizational perspective, BIM compatibility refers to the extent to which an organization's workflows, work methods, and tasks of design engineers need to be modified to meet the requirements of BIM implementation [41]. From a technical perspective, BIM compatibility is concerned with the interoperability between different BIM software [41]. The application of BIM in engineering design can improve the quality of design solutions and enhance collaborative design efficiency, but it also leads to an increase in workload [23] and a redistribution of responsibilities. The most critical characteristic of status quo bias is the individual's biased and irrational evaluation of the information system [11]. This means neglecting the opportunities presented by the new information system while amplifying the perceived threats it introduces. Therefore, design engineers with a higher tendency to resist change are more likely to internally ignore the advantages of BIM while deliberately exaggerating the negative changes it introduces. An increased resistance to adopting BIM is associated with a decreased perception of its compatibility.

BIM user satisfaction reflects construction professionals' overall assessment of the positive and negative aspects of BIM implementation during its diffusion [42]. Design engineers with a strong tendency to resist change are likely to amplify their negative perceptions of BIM while downplaying the positive aspects, resulting in lower satisfaction with the current BIM implementation environment and outcomes. Previous research has shown that increased BIM compatibility enhances design engineers' perceived usefulness of the technology [16]. Furthermore, the perceived usefulness of BIM is a significant determinant of BIM user satisfaction [43]. Consequently, design engineers' perception of BIM's compatibility with their existing tasks and workflows is positively associated with their satisfaction with the current BIM implementation environment. Based on this, the following hypotheses are formulated:

H2a: *Design engineers' resistance to change toward BIM implementation is negatively associated with BIM compatibility.*

H2b: *Design engineers' resistance to change toward BIM implementation is negatively associated with BIM user satisfaction.*

H3: *Design engineers' BIM compatibility is positively associated with BIM user satisfaction.*

2.2.5. The Impact of BIM Implementation on Resistance Behavior

The Expectation–Confirmation Model suggests that higher levels of perceived usefulness and user satisfaction with an information system contribute to a greater intention to continue its use [44]. Similarly, Ma et al. found that construction professionals' willingness to continue using BIM is positively associated with their evaluation of the benefits

generated by BIM [45]. This, in turn, promotes both exploitative and exploratory BIM use behaviors, leading to more frequent and positive engagement with BIM. Therefore, higher BIM compatibility and satisfaction are likely to elicit positive usage behaviors and mitigate resistance behaviors among design engineers. Therefore, the following hypothesis is proposed:

H4a: *Design engineers' BIM compatibility is negatively associated with their behavioral resistance to BIM implementation.*

H4b: *Design engineers' BIM user satisfaction is negatively associated with their behavioral resistance to BIM implementation.*

2.2.6. The Impact of Status Quo Bias on Behavioral Resistance to BIM Implementation

The status quo bias can significantly impede the adoption of new information systems [11]. Users with a greater propensity to resist change often struggle to deviate from established work practices. When confronted with a novel information system, they experience heightened emotional distress and are less inclined to alter their mindset, rendering them more reluctant to adopt the new system. In mandatory usage contexts, Laumer et al. [46] noted that employees with a high resistance to change directly exhibit resistant behaviors towards the new system. Given that the promotion of BIM in engineering design firms is predominantly driven by authoritative decision making, design engineers with a stronger tendency to resist change are more likely to exhibit negative resistance behaviors towards BIM implementation. Based on this, the following hypothesis is proposed:

H5: *Design engineers' resistance to change toward BIM is positively associated with their behavioral resistance to BIM implementation.*

3. Research Method

3.1. Measurement Development

This research is fundamentally grounded in Positivist Epistemology. Unlike Interpretive Epistemology, which prioritizes the exploration of subjective meanings attributed by individuals and groups, Positivist Epistemology asserts that knowledge should be based on observable and measurable objective facts, with an emphasis on identifying universal causal laws. Consistent with its objective of generating objective and replicable scientific knowledge, Positivist Epistemology predominantly utilizes quantitative research methodologies. These methods focus on formulating hypotheses or causal relationships between variables and employ data collection alongside statistical analysis to validate and elucidate these relationships. Among the various quantitative techniques, the questionnaire survey is frequently employed as a standard research instrument.

To assess the previously developed research model and its corresponding hypotheses, a questionnaire survey was utilized as the principal method for data collection. The development of variable measurement commenced with a comprehensive review of both theoretical and empirical literature pertaining to BIM, complemented by semi-structured interviews conducted in April 2025 with four experts from academic and industry backgrounds. Subsequent to the initial formulation of the measurement items, a pretest was conducted using the online survey platform wjx.cn to identify any ambiguous phrasing and to perform a preliminary evaluation of the validity of the related constructs. Subsequent to the feedback obtained from participants, several measurement items within the questionnaire were refined accordingly.

The final questionnaire was composed of three sections. The first section gathered general information pertaining to the project engineer, including gender, educational background, experience within the construction industry, and experience with BIM implementation. The second part evaluates the resistance behaviors of the surveyed design engineers related to BIM implementation. The third part comprises questions on the six examined contextual factors. A total of seven dependent or independent variables were measured in the questionnaire: inertia (BI), self-efficacy (SEF), perceived distributive equity (PDE), resistance to change (RTC), BIM compatibility (COM), BIM user satisfaction (SAT), behavioral resistance to BIM implementation (BRE).

The measurement items for the constructs were primarily sourced from well-established scales in the existing literature, recognized for their reliability, and were subsequently modified to suit the context of BIM. Table 2 shows each construct and its theoretical source, as well as specific wording adjustments for the BIM context. Table 3 provides a comprehensive overview of all constructs, including the corresponding scales and their source references. The particular measurement items employed in this study are also delineated within Table 3.

Table 2. Construct Sources, Theoretical Foundations, and Adaptation Details.

Construct	Theoretical Source	Original Scale Reference	Adaptation Details for BIM Context
Inertia (BI)	Status Quo Bias (SQB)—Cognitive Misperception	Polites and Karahanna [34]	Change the inertia regarding information systems to the BIM context
Self-Efficacy (SEF)	Social Cognitive Theory—Self-Control	Kim and Kankanhalli [47]	Adapted “working with the NOP system” to “BIM software (or platform)”
Perceived Distributive Equity (PDE)	Equity Theory—Rational Decision Making	Wang et al. [26]	Both are studies in the BIM context, emphasized “benefits distribution in design teams”.
Resistance to Change (RTC)	SQB—Psychological Commitment	Zhang et al. [24]	The reference is the item on the willingness to use BIM in this article, which has been slightly modified to adapt to the research in this paper
BIM Compatibility (COM)	Innovation Diffusion Theory—Compatibility	Ahmed and Kassem [41]	Both are studies in the BIM context, emphasized “in design teams”.
BIM User Satisfaction (SAT)	Expectation–Confirmation Model (ECM)	Song et al. [42]	Both are studies in the BIM context, emphasized “in design teams”.
Behavioral Resistance (BRE)	Human–System Interaction Theory	Wang et al. [26]	Both are studies in the BIM context, emphasized “in design teams”.

Table 3. Measurement items.

Dimension	Constructs	Measurement Question Items	Item Source
Inertia (BI)	BI1	I will continue using the existing traditional software (or platform) to complete my work because it makes me feel comfortable.	Polites and Karahanna [34]
	BI2	I will continue using the existing traditional software (or platform) to complete my work because I prefer doing so.	
	BI3	I will continue using the existing traditional software (or platform) to complete my work simply because I have always done so in the past.	

Table 3. Cont.

Dimension	Constructs	Measurement Question Items	Item Source
Self-Efficacy (SEF)	SEF1	Given my current level of knowledge and skills, using BIM software (or platform) in my work is easy and straightforward for me.	Kim and Kankanhalli [47]
	SEF2	Even without assistance from others, I can use BIM software (or platform) to complete the relevant tasks.	
	SEF3	I can successfully use BIM software (or platform) to complete the relevant tasks on my own.	
Perceived distributive equity (PDE)	PDE1	During the implementation of BIM in projects, the company fairly provides the necessary resources to both my colleagues and me.	Wang et al. [26]
	PDE2	In projects where BIM is applied, my colleagues and I receive the same benefits, and these are distributed fairly.	
	PDE3	The company has compensated for the increased workload resulting from the implementation of BIM.	
	PDE4	The benefits my colleagues and I gain from BIM are proportional to the effort we invest in its implementation.	
	PDE5	The BIM-related tasks in the project are fairly distributed between my colleagues and me.	
Resistance to change (RTC)	RTC1	I generally perceive the impacts of BIM-related changes as negative.	Zhang et al. [24]
	RTC2	I prefer sticking to the software or platform I am familiar with rather than trying to use BIM software (or platform).	
	RTC3	If I were told that all construction companies are required to use BIM for project implementation, I would feel pressured.	
	RTC4	I feel nervous as soon as I hear about the implementation of BIM technology.	
	RTC5	Using BIM feels like a hassle to me.	
	RTC6	Even though I know that BIM changes would benefit my work, I often avoid adopting it.	
	RTC7	Even though I know that BIM changes would benefit my work, I often feel uncomfortable with adopting it.	
	RTC8	Once I start using a particular software (or platform) for work, I am unlikely to switch to another one.	
BIM compatibility (COM)	COM1	BIM software (or platform) has good compatibility with the existing software.	Ahmed and Kassem [41]
	COM2	Using BIM aligns well with my working style.	
	COM3	Using BIM is well-suited to my job tasks.	
	COM4	BIM can easily be integrated into the existing workflow.	
BIM user satisfaction (SAT)	SAT1	The conditions/environment for BIM application generally meet your expectations.	Song et al. [42]
	SAT2	The conditions/environment for BIM application exceed your expectations.	
	SAT3	You are very satisfied with the conditions/environment for your BIM application.	
Behavioral resistance to BIM implementation (BRE)	BRE1	I often do not comply with the changes in work methods brought about by the application of BIM in projects.	Wang et al. [26]
	BRE2	I often find excuses to delay the implementation and application of BIM in projects.	
	BRE3	I have already expressed my opposition to the changes in work methods brought about by the application of BIM in the project to my superiors.	
	BRE4	I often complain to my colleagues about the changes in work methods brought about by the application of BIM in the project.	
	BRE5	I often oppose the changes in work methods brought about by the application of BIM in the project.	

The measurement items for BI were adapted from the papers of Polites and Karahanna [34], and subsequently modified to align with the context of BIM. The four adopted items specifically reflect the intention of design engineers continuing using the incumbent system or platform. The measurement items of SEF were based on Kim and Kankanhalli [47], and were subsequently adapted to align with the context of BIM. A total of three items were ultimately utilized to assess this construct, focusing on the design engineers' subjective judgment of whether they can successfully use BIM. The operationalization of PDE was primarily informed by the works of Wang et al. [26]. The construct of PDE was operationalized to illustrate the perceived fairness of outcome distributions during the implementation of BIM in construction projects. The items of the RTC were based on the works of Zhang et al. [24], with eight items measuring the negative responses toward BIM implementation. The measurement items of COM were adapted from Ahmed et al. [41]. Four items reflect the consistency of BIM with existing values, past experiences and needs of design engineers. The measurement items of SAT were based on Song et al. [42]. The items reflect the extent to which design engineers believe that the BIM implementation to them meets their requirement. The measurement items of BRE were based on Wang et al. [26], with five items reflecting the behavioral resistance in the context of BIM implementation in construction projects. BRE is measured using a self-reporting method, which conforms to the research conventions in the field of information systems [26]. To reduce social approval and memory bias, the survey was conducted in a completely anonymous manner, and it was clearly stated that "there are no right or wrong answers, and they are only for academic research." All behavior items are described using frequency (such as "often") instead of binary choices to improve the accuracy of the report. In addition, respondents were asked to answer based on the most recent complete BIM project (with an average cycle of more than six months) to reduce recall bias. All variables were operationalized as reflective constructs, each measured using multiple items on a five-point Likert scale, ranging from "1 = strongly disagree" to "5 = strongly agree".

3.2. Sampling and Data Collection

The survey questionnaire was distributed to design engineers actively engaged in BIM-based construction projects within mainland China. As one of the largest construction markets globally, China's construction output value reached RMB 32.65 trillion (approximately US\$ 4.59 trillion based on the 2024 exchange rate). In recent years, the Chinese government has introduced a range of initiatives aimed at encouraging the adoption of BIM. Nevertheless, the advancement of BIM within the construction sector continues to exhibit significant regional disparities. As a result, the use of a purely random sampling approach was considered unsuitable for respondent selection. Instead, participants were purposively identified to represent a broad spectrum of BIM-based construction projects across different geographic areas. This identification process involved multiple methods, including searches within BIM-focused communication platforms and outreach to professionals attending industry conferences. The selected individuals were then invited to complete a survey, reflecting on their most recent involvement in a construction project employing BIM technology.

Prior to the administration of a comprehensive questionnaire survey, in-depth interviews were conducted with four experts possessing substantial theoretical knowledge and practical experience in BIM. Among these experts, two were academic researchers specializing in BIM, demonstrating an extensive understanding of BIM adoption within the industry. The remaining two participants were practitioners from construction firms actively engaged in BIM implementation. During the interviews, the experts were asked to discuss resistance behaviors associated with BIM adoption, provide practical examples of

such behaviors, and identify the underlying factors contributing to this resistance. Subsequently, the experts were requested to assess the questionnaire to establish its face validity and to ensure that the measurement items were pertinent to the construct of behavioral resistance toward BIM. Each interview session lasted approximately 45 min to one hour.

Subsequently, a comprehensive questionnaire survey was conducted to collect relevant data. Responses were obtained through email and the online survey platform wjx.cn between April 2025 and June 2025. Approximately 340 construction engineers from diverse regions were contacted via wjx.cn, email, and WeChat, resulting in the acquisition of 252 completed questionnaires. To ensure the integrity of the data, this study strictly filtered out some questionnaires with low-quality responses and eliminated 55 invalid cases from the initial 252 completed questionnaires. The filtering criteria were operationalized as follows: (1) responses with predominant single-option selections (e.g., the same answer choice used for 80% or more of the items); (2) those exhibiting excessive neutral answers (defined as selecting the midpoint ‘3’ on the 5-point Likert scale for 70% or more of the items, indicating potential disengagement); (3) questionnaires with any unanswered items; and (4) surveys completed in less than 150 s, as this duration was deemed insufficient for thoughtful completion based on pretest timing averages (mean completion time: 8.2 min). This process yielded 197 valid responses, achieving an effective response rate of 78.2%. Demographic analyses were performed using IBM SPSS Statistics version 22.0, with the characteristics of the 197 design engineers summarized in Table 4. The data reveal that 54.31% of participants have more than six years of experience with BIM. Additionally, the sample demonstrates diversity in terms of gender and BIM experience levels among the surveyed engineers.

Table 4. Sample characteristics.

Variable	Category	Number	Percentage
Gender	Male	143	72.59%
	Female	54	27.41%
Educational background	Junior college and below	16	8.12%
	Undergraduate	122	61.93%
	Master’s degree	54	27.41%
	Ph.D.	5	2.54%
Experience in BIM implementation	0–5 years	90	45.69%
	6–10 years	88	44.67%
	11 years and above	19	9.64%
Experience in the Construction industry	0–5 years	114	57.87%
	6–10 years	62	31.47%
	11 years and above	21	10.66%

4. Data Analyses and Results

4.1. Measurement Validation

Utilizing the gathered data, this study employed partial least squares structural equation modeling (PLS-SEM) to investigate the underlying predictive pathways of behavioral resistance to BIM through the application of path analysis among the relevant variables. The research model posits linear associations between constructs. This assumption is well-suited to PLS-SEM, which effectively models continuous, interval-scaled data (e.g., 5-point Likert responses) without requiring multivariate normality or large samples. With a sample of 197 responses, PLS-SEM is appropriate for relatively small samples [48], unlike covariance-based SEM (CB-SEM), which requires larger samples and assumes multivariate

normality. PLS-SEM focuses on maximizing explained variance in endogenous constructs, aligning with our predictive-exploratory objectives [49], whereas CB-SEM is better for confirmatory testing of well-established theories. Regarding the required sample size for performing PLS analyses, it is recommended that the sample size be no less than ten times the number of structural paths directed toward the latent construct with the greatest number of incoming paths [50]. In the current paper, the construct exhibiting the highest number of incoming paths is the BRE, which has a total of ten incoming paths, and the sample size ($N = 197$) satisfactorily meet the “10 times” requirement. Before applying the Partial Least Squares (PLS) method to test the proposed hypotheses, the measurement instruments corresponding to the variables involved in the hypotheses were first subjected to a validation procedure.

The measurement validation for BI, SEF, PDE, RTC, COM, SAT, and BRE was performed through the assessment of internal consistency, convergent validity, and discriminant validity. Internal consistency of the constructs was examined by computing composite reliability. As presented in Table 5, the composite reliability coefficients for the examined constructs exceed the conventional benchmark of 0.7 [49], indicating that each construct exhibits satisfactory internal consistency. Convergent validity, which assesses the degree to which the items associated with a given construct represent the same underlying theoretical concept, was evaluated through the computation of average variance extracted (AVE) values alongside the factor loadings of the measurement items. Table 5 further illustrates that the AVE values for all constructs surpass the recommended threshold of 0.5 [49]. The square root of the average variance extracted (AVE) for each construct surpasses the absolute values of the inter-construct correlations, indicating adequate discriminant validity among the constructs. As presented in Table 6, most items exhibit standardized factor loadings on their respective constructs exceeding the 0.7 threshold [49]. This finding suggests that the observed variables possess substantial explanatory power for their associated latent constructs.

Table 5. Measurement validity and construct correlations.

Variable	Mean	SD	CR	AVE	Correlation Matrix ^a						
					BI	SEF	PDE	RTC	COM	SAT	BRE
BI	2.964	0.580	0.864	0.773	0.879						
SEF	3.243	0.931	0.934	0.883	0.145	0.940					
PDE	3.120	0.577	0.952	0.747	−0.212	0.091	0.864				
RTC	2.668	0.721	0.950	0.700	0.535	−0.142	−0.527	0.837			
COM	2.972	0.633	0.853	0.647	−0.215	0.329	0.532	−0.498	0.804		
SAT	2.987	0.529	0.776	0.664	−0.356	0.002	0.439	−0.465	0.482	0.815	
BRE	2.385	0.674	0.920	0.753	0.440	−0.101	−0.592	0.602	−0.525	−0.520	0.868

Notes: SD (standard deviation) = $\frac{1}{N} \sum_{i=1}^N (x_i - \mu)^2$; CR (composite reliability) = $\frac{(\sum \lambda)^2}{[(\sum \lambda)^2 + \sum \theta]}$; AVE (average variance extracted) = $\frac{\sum_{i=1}^n \lambda_i^2}{\sum_{i=1}^n \lambda_i^2 + \sum_{i=1}^n \theta_i}$. ^a Bold values on the diagonal represent the square root of AVE.

Table 6. Factor loadings for multi-item constructs.

Construct	Items	Mean	SD ^a	Standardized Factor Loadings ^b							T-Value
				BI	SEF	PDE	RTC	COM	SAT	BRE	
BI	BI1	3.066	0.543	0.841	0.099	−0.219	0.502	−0.258	−0.239	0.429	26.551
	BI2	2.944	0.589	0.883	0.123	−0.075	0.398	−0.204	−0.282	0.284	20.631
	BI3	2.807	0.952	1.432	0.161	−0.243	0.497	−0.106	−0.413	0.427	20.850
SEF	SEF1	3.442	0.936	0.163	0.954	0.037	−0.134	0.250	−0.030	−0.052	12.449
	SEF2	3.228	1.054	0.141	1.080	0.072	−0.134	0.288	0.021	−0.085	12.635
	SEF3	3.046	0.989	0.106	0.973	0.148	−0.133	0.390	0.014	−0.147	11.283

Table 6. Cont.

Construct	Items	Mean	SD ^a	Standardized Factor Loadings ^b							T-Value
				BI	SEF	PDE	RTC	COM	SAT	BRE	
PDE	PDE1	3.452	0.656	0.010	0.305	0.890	−0.313	0.515	0.246	−0.362	16.528
	PDE2	3.234	0.567	−0.125	0.204	0.868	−0.429	0.561	0.382	−0.562	26.221
	PDE3	2.832	0.877	−0.356	−0.031	1.363	−0.594	0.417	0.413	−0.603	26.686
	PDE4	3.030	0.683	−0.218	−0.020	1.085	−0.491	0.447	0.446	−0.551	35.706
	PDE5	3.142	0.533	−0.099	0.054	0.771	−0.360	0.403	0.368	−0.409	15.747
RTC	RTC1	2.584	0.950	0.385	−0.032	−0.565	0.977	−0.495	−0.391	0.638	19.073
	RTC2	2.964	0.845	0.467	−0.206	−0.369	1.009	−0.506	−0.292	0.488	30.769
	RTC3	2.655	0.851	0.337	−0.267	−0.510	0.960	−0.385	−0.306	0.308	19.413
	RTC4	2.472	0.803	0.257	−0.304	−0.308	0.878	−0.241	−0.172	0.204	15.174
	RTC5	2.721	0.836	0.442	−0.264	−0.553	1.065	−0.560	−0.507	0.590	31.562
	RTC6	2.629	0.912	0.562	−0.052	−0.393	1.166	−0.345	−0.435	0.557	37.432
	RTC7	2.467	0.828	0.545	0.008	−0.483	1.049	−0.373	−0.491	0.574	27.277
	RTC8	2.802	0.816	0.506	0.094	−0.247	0.805	−0.315	−0.388	0.485	11.914
COM	COM1	3.091	0.598	−0.087	0.221	0.277	−0.172	0.655	0.184	−0.235	9.976
	COM2	3.051	0.711	−0.179	0.204	0.438	−0.379	0.971	0.306	−0.486	20.434
	COM3	2.975	0.892	−0.224	0.386	0.458	−0.511	1.127	0.511	−0.389	24.730
	COM4	2.817	0.835	−0.160	0.224	0.476	−0.426	1.116	0.441	−0.505	25.094
SAT	SAT1	3.513	0.500	−0.222	−0.002	0.244	−0.333	0.235	0.694	−0.378	15.292
	SAT2	2.376	0.669	−0.234	−0.098	0.371	−0.324	0.409	1.096	−0.386	21.301
	SAT3	2.990	0.780	−0.383	0.081	0.429	−0.458	0.491	1.235	−0.490	33.445
BRE	BRE1	2.538	0.893	0.463	0.017	−0.529	0.506	−0.477	−0.446	1.206	38.051
	BRE2	2.360	0.779	0.339	−0.183	−0.489	0.556	−0.444	−0.448	0.987	34.748
	BRE3	2.376	0.755	0.413	−0.004	−0.553	0.437	−0.507	−0.486	0.970	32.266
	BRE4	2.487	0.882	0.476	−0.003	−0.469	0.616	−0.401	−0.491	1.153	37.054
	BRE5	2.218	0.620	0.199	−0.280	−0.538	0.485	−0.456	−0.380	0.758	23.230

Notes: Bold values represent standardized factor loadings of the items on their respective constructs, and T-values are for these loadings. ^a SD = standard deviation. ^b All factor loadings are significant at the 0.1% level.

4.2. Hypothesis Testing

One of the concerns regarding formative measurement constructs is the multicollinearity among the formative indicators of each construct. Therefore, we tested the multicollinearity of all structures in the model. All the formed variance inflation factor (VIF) values range from 1.00 to 1.48. This is far below the 3.3 threshold proposed by Diamantopoulos and Siguaw [51] as well as Petter et al. [52], indicating that there is no serious multicollinearity problem in the data. A bootstrapping method comprising 5000 resamples was employed to evaluate the statistical significance of the path coefficients in the research model. The results, as shown in Figure 2, indicate that the R^2 values for resistance to change and behavioral resistance to BIM implementation are 0.494 and 0.469, respectively. This suggests that a significant portion of the variance in this construct is accounted for by the research model. The relevant path coefficients can be seen in Table 7. Inertia ($\beta = 0.473$, significant at the 0.001 level, $f^2 = 0.410$) has a positive association with resistance to BIM, while self-efficacy ($\beta = -0.173$, significant at the 0.01 level, $f^2 = 0.057$) has a negative association with resistance to change toward BIM implementation. Additionally, perceived distributive equity ($\beta = -0.411$, significant at the 0.001 level, $f^2 = 0.313$) has a negative association with resistance to change toward BIM implementation. Thus, the results for all three variables are significant, providing support for hypotheses H1a, H1b, and H1c. At the same time, it demonstrates that BI is the strongest predictor for RTC and the core of the SQB mechanism, reflecting engineers' extremely strong "stickiness" to traditional tools. However, SEF has a weak buffering effect on RTC, which may be masked by stronger factors such as BI. As for PDE, it emphasizes that the fairness concern over the redistribution of BIM work is a key psychological barrier. Regarding the impact of resistance to change on BIM implementation, we hypothesize that resistance to change is negatively correlated with BIM compatibility (Hypothesis H2a) and BIM user satisfaction (Hypothesis H2b). As

clearly shown in Figure 2, the path coefficient of resistance to change on BIM compatibility is $\beta = -0.498$, significant at the 0.001 level, $f^2 = 0.330$. The path coefficient for the impact of resistance to change on BIM user satisfaction is $\beta = -0.299$, also significant at the 0.001 level, $f^2 = 0.096$. Additionally, the path coefficient for the impact of BIM compatibility on BIM user satisfaction is $\beta = 0.333$, significant at the 0.001 level, $f^2 = 0.119$. Therefore, Hypotheses H2a, H2b, and H3 are all supported. As for the impact of BIM compatibility and user satisfaction on behavioral resistance to BIM implementation, Figure 2 shows that their path coefficients are $\beta = -0.21$ and $\beta = -0.236$, respectively, both significant at the 0.01 and 0.001 levels, $f^2 = 0.062$ and $f^2 = 0.073$, supporting Hypotheses H4a and H4b. Lastly, resistance to change is positively correlated with behavioral resistance to BIM implementation, with a path coefficient of $\beta = 0.383$, significant at the 0.001 level, $f^2 = 0.189$, thus supporting Hypothesis H5. Therefore, it can be concluded that psychological resistance erodes the perception of technical fit, and at the same time, psychological resistance indirectly weakens satisfaction. RTC $\rightarrow$ BRE, as a key bridge, has confirmed that psychological resistance is transformed into practical actions. This effect has also, to a certain extent, masked the role of technical compatibility and satisfaction with technology at the behavioral level.

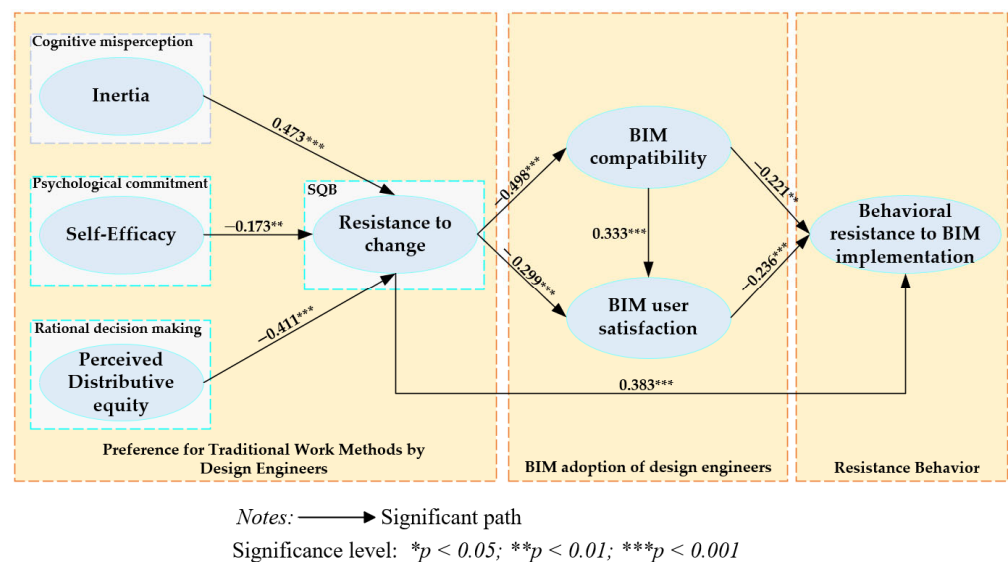


Figure 2. Results of PLS analyses for the research model.

Table 7. Hypothesis standard path coefficient and test results.

Hypothesis	Path	Standard Path Coefficient	p -Value	f^2	Test Result
H1a	Inertia—Resistance to change	0.473	0.000	0.410	support
H1b	Self-Efficacy—Resistance to change	−0.173	0.006	0.057	support
H1c	Perceived Distributive equity—Resistance to change	−0.411	0.000	0.313	support
H2a	Resistance to change—BIM compatibility	−0.498	0.000	0.330	support
H2b	Resistance to change—BIM user satisfaction	−0.299	0.000	0.096	support
H3	BIM compatibility—BIM user satisfaction	0.333	0.000	0.119	support
H4a	BIM compatibility—Behavioral resistance to BIM implementation	−0.221	0.005	0.062	support
H4b	BIM user satisfaction—Behavioral resistance to BIM implementation	−0.236	0.001	0.073	support
H5	Resistance to change—Behavioral resistance to BIM implementation	0.383	0.000	0.189	support

5. Discussion

5.1. Key Findings

5.1.1. Differential Influence of Various Dimensions on SQB Formation

The findings of this study demonstrate that inertia, self-efficacy, and perceived distributive equity each exert a significant influence on resistance to change. This prediction is consistent with theoretical expectations. These findings are consistent with the results of Hsieh et al. [36]. Users tend to develop resistance to change towards a new information system through the combined effects of cognitive misperception, psychological commitment, and rational decision making. This also suggests that the study by Zhang et al. [24], which focuses solely on resistance to change from the perspective of psychological capital (specifically the psychological commitment dimension), has certain limitations. Additionally, unlike Gong et al. [53], who suggest that inertia should be regarded as the ultimate manifestation of status quo preference, this study shows that inertia, self-efficacy, and perceived distributive equity collectively contribute to the formation of resistance to change, with an R^2 value of 0.494. This indicates that resistance to change, as the ultimate manifestation of status quo preference, has strong explanatory power. This implies that design engineers' inclination towards current information systems and work methods is not solely due to inertia but is instead influenced by a multifaceted psychological condition.

Inertia is strongly associated with design engineers' resistance to change ($\beta = 0.473$, significant at the 0.001 level), a result that aligns with Hsieh [36]. This positive association indicates that entrenched habits with existing systems create a powerful psychological anchoring effect. From an organizational psychology perspective, inertia exceeds mere habit and instead reflects a psychological commitment to familiar workflows that affords stability and predictability. Design engineers who have used traditional software such as AutoCAD for many years develop cognitive comfort with those tools, which fosters negative attitudes toward BIM adoption. Consequently, they may downplay benefits of BIM because the cognitive effort required to reconfigure mental models elicits defensive responses to change. Identifying inertia as the principal driver of resistance corroborates Polites et al. [34], who also found inertia to be a major barrier to new information system implementation. Thus, despite advances in BIM, design engineers continue to favor traditional methods, indicating that overcoming inertia will require addressing deep-seated cognitive and emotional attachments.

The hypothesis that self-efficacy influences design engineers' resistance to change is strongly supported ($\beta = -0.173$, significant at the 0.01 level), aligning with Zhang et al. [24]. This negative correlation highlights the pivotal role self-efficacy plays in reshaping emotional responses to technological change. According to social cognitive theory, individuals with higher self-efficacy have greater confidence in their ability to tackle new challenges, which directly reduces anxiety and defensiveness during digital transformation. For design engineers, adopting BIM involves mastering new workflows and software, presenting a significant competence challenge. Those with higher self-efficacy view this transition as an opportunity for growth rather than a threat, leading to less psychological distress and resistance. This finding supports self-efficacy theory, which suggests that such individuals are more likely to engage in adaptive behaviors and persist through initial challenges, thereby reducing negative emotional reactions to change. Essentially, self-efficacy acts as an emotional buffer, enabling engineers to view the challenges of BIM adoption as manageable obstacles rather than insurmountable threats.

The significant negative relationship between perceived distributive equity and resistance ($\beta = -0.411$, significant at the 0.001 level) supports Hypothesis H1c, emphasizing the crucial role of fairness perceptions in mitigating defensive attitudes toward organizational change. This finding aligns with Markus' [31] view that users' rational evaluations of new

systems encompass not only technical characteristics but also assessments of benefit distribution fairness. The strength of this relationship, second only to inertia, highlights how perceived inequity in task distribution, compensation for increased workload, or benefits derived from BIM usage can trigger psychological contract violations, thus intensifying resistance. This observation corresponds with organizational support theory, which posits that employees perceiving fair treatment develop a stronger affective commitment to the organization, making them more receptive to changes implemented by the organization. In the context of BIM implementation, when design engineers believe their additional efforts will be fairly compensated and recognized, their rational calculations shift toward acceptance, reducing defensiveness. This also aligns with Wang et al. [26], who suggested that BIM resistance stems from technical-fairness interactions, and with Yan et al. [54], who noted that fairness perceptions in contractual compensation influence behavior. The stronger the perceived inequity, the greater the resistance tendency, illustrating how distributive justice perceptions can either alleviate or exacerbate defensive attitudes toward technological change.

5.1.2. Resistance to Change Negatively Impacts BIM Implementation

The findings from the data analysis in this study indicate that resistance to change exerts a significant negative effect on both BIM compatibility ($\beta = -0.498, p < 0.001$) and BIM user satisfaction ($\beta = -0.299, p < 0.001$). This observation aligns with the findings reported by Chi et al. [55], which suggest that resistance to change negatively affects the adoption of information systems. The stronger the resistance to BIM implementation among design engineers, the more unwilling they are to break away from their conventional work environment. When faced with change, they experience significant emotional stress and find it difficult to alter their mindset [56]. They may believe that BIM cannot be easily integrated into their existing tasks and workflows. It is worth noting that the emergence of resistance to change can make design engineers more likely to doubt the compatibility of BIM with their work. Additionally, it can lead to dissatisfaction with the current conditions and environment for BIM implementation.

In comparison to the study by Ma et al. [45], which suggests that in the post-BIM implementation phase, perceived usefulness and satisfaction are key indicators for measuring the degree of BIM implementation, it is also found that an increase in perceived usefulness of BIM leads to higher user satisfaction. Therefore, in this study, BIM compatibility has a significant associate with BIM user satisfaction ($\beta = 0.333$, significant at the 0.001 level). Expanding on this idea, in this study, BIM compatibility has a significant associate with BIM user satisfaction. The higher the degree of compatibility between BIM and the existing tasks and workflows of design engineers [57], and the stronger the data interaction capabilities between BIM software and traditional design software, the greater the satisfaction of design personnel with the current BIM application environment. This means that factors influencing BIM implementation differ at various stages (adoption stage vs. post-adoption stage), and classic information system adoption models (e.g., TAM, Expectation-Confirmation Model) cannot be directly applied. Instead, a detailed analysis of the specific adoption context should be conducted to identify the appropriate variables for analysis. During the BIM implementation stage, companies not only consider how BIM can enhance work performance, but are also influenced by internal institutional pressures to adopt BIM [18]. Therefore, compared to the improvement in work performance brought by BIM, design engineers are more concerned about whether BIM can seamlessly integrate into their existing workflows and whether it is compatible with their core responsibilities [58].

5.1.3. Resistance to Change as the Predominant Factor in Shaping Behavioral Resistance

As previously mentioned, the path coefficient of resistance to change to behavioral resistance to BIM implementation is $\beta = 0.383$, significant at the 0.001 level, supporting Hypothesis H5. It is worth noting that, unlike the findings of Zhang et al. [24], which suggest that resistance to change influences BIM implementation behavior through the mediating effect of BIM implementation intention, the results of this study confirm that design engineers with higher resistance to change directly exhibit resistance behaviors towards the application of BIM technology. This is consistent with the findings of Laumer et al. [46], which suggest that in mandatory usage contexts, users with a high tendency to resist change are more likely to exhibit resistance behaviors toward the use of new information systems. The reason for this direct effect is that BIM technology is adopted through an authoritative innovation approach. Once the leaders decide to implement BIM, design engineers are required to use it and do not have the autonomy to decide whether or not to adopt BIM. The analysis of the data further reveals that resistance to change constitutes the primary factor influencing the development of behavioral resistance to BIM implementation. Additionally, the empirical findings demonstrate that both compatibility and satisfaction exert a negative effect on behavioral resistance to BIM implementation. This indicates that the more compatible BIM is with the tasks and workflows of design engineers, and the more satisfied they are with the current BIM implementation environment, the less likely they are to exhibit resistance behaviors. The R^2 value of 0.469 for Behavioral resistance to BIM implementation formed by resistance to change, compatibility, and satisfaction indicates that during the BIM implementation stage, the resistance behaviors of design engineers are influenced not only by technical factors (such as compatibility and satisfaction), but also by the interaction of psychological, cognitive, and fairness-related factors. This is consistent with the findings of Wang et al. [26], who assert that Behavioral resistance to BIM implementation is driven by both technical and fairness-related factors.

5.2. Theoretical Contributions

Compared to previous research, two theoretical contributions are made. First, this study provides a novel perspective on research into BIM diffusion. Previous research has largely viewed BIM as an isolated technical innovation, typically identifying antecedent variables of BIM implementation or resistance by analyzing construction professionals' direct perceptions, such as perceived ease of use and perceived usefulness. In contrast, this study offers a thorough examination of the influence of status bias on user resistance to the implementation of BIM within construction projects, highlighting the reluctance to transition from conventional design approaches to BIM-driven design processes. It highlights the role of resistance to change toward BIM in the formation of behavioral resistance, thereby expanding the research perspective on BIM diffusion. As BIM-based design methods in engineering gradually replace, either partially or entirely, traditional design approaches, the status quo bias of design engineers toward traditional methods poses a significant barrier to extensive BIM adoption. Drawing on the Status Quo Bias, this study clarifies the predictive pathways linking this bias to BIM implementation and resistance behaviors, investigating the specific pathways leading to behavioral resistance. More importantly, this behaviorally grounded explanation for resistance fills a critical gap in understanding digital transformation failures in the construction industry, which often arise from nontechnical factors such as organizational culture and individual resistance to change. These findings can serve as a reference for understanding the mechanisms of behavioral resistance in information systems more broadly.

Secondly, this study broadens the application of the SQB framework to explain the behavioral resistance encountered during BIM implementation. While previous research

on status quo bias has mainly addressed transitions between legacy and new healthcare information systems or shifts between online and offline service platforms, this study confirms that the SQB framework effectively explains the resistance to BIM implementation. This resistance stems from changes in design engineers' work practices. The findings demonstrate that status quo bias emerges when transitioning from traditional engineering design methods to BIM-based approaches. By applying and validating the SQB framework in this context, our study lays a conceptual foundation for future BIM adoption research. It offers a theoretical perspective for systematically analyzing the behavioral mechanisms behind digital transformation failures in construction, moving beyond purely technological or organizational views.

5.3. Practical Implications

This study offers several practical implications. Firstly, it identifies resistance to change as the main obstacle hindering BIM adoption in engineering design. Project managers should implement strategies to reduce this resistance. Currently, integrating BIM into engineering design workflows extends project timelines and increases workloads for design engineers. At the organizational level, appropriate BIM incentive policies should be established to offset the sunk costs of existing methods and the switching costs of adopting BIM. For example, project managers should raise salary standards for design engineers involved in BIM projects, offering favorable considerations for career advancement and performance evaluations. Additionally, the evaluation criteria for design engineers in BIM projects should be moderately relaxed. BIM-integrated design tools should be introduced to gradually phase in new workflows rather than imposing abrupt changes. Moreover, when forming BIM project teams, priority should be given to selecting design engineers with a strong willingness to adopt BIM. Their enthusiasm can inspire others, improve team communication, and reduce negative sentiments within the BIM project team. Organizations should also incorporate psychological support mechanisms, including digital transition counseling and peer mentoring programs, to assist engineers in managing emotional stress.

Secondly, addressing distributive inequity in the allocation of BIM workload to design engineers is essential. Project managers must ensure a fair and balanced distribution of BIM tasks, providing appropriate rewards for those managing more substantial responsibilities. Establishing transparent performance metrics and assessment criteria can enhance the perceived fairness in distributing the benefits of BIM implementation. Additionally, implementing collaborative training initiatives for BIM design can enhance the confidence and skills of design engineers. In addition to project-level measures, policymakers should create incentive structures that reward participation in innovation, such as offering tax benefits to firms reaching specific BIM maturity levels or providing grants for sustainable BIM projects. These incentives could help alleviate perceived distributive inequity and promote a culture of innovation.

Thirdly, many architectural firms rely on established BIM platforms such as Revit, yet poor data compatibility across software remains a persistent problem. When procuring software with compatible data formats is not feasible during project acquisition, developing targeted plugins can mitigate efficiency losses caused by incompatibility. In addition, project-level BIM standards and procedures should be defined according to engineers' specific tasks to improve alignment between BIM and their workflows.

Fourth, due to the significant influences of BIM user satisfaction, project managers should increase their satisfaction when managing BIM implementation process. When engineering designers utilize BIM, the core objective is to manage the diverse information outputs required for the digital model. It is essential to enhance the information management capabilities of construction projects by leveraging BIM software or platforms, and

provide engineering designers with various information reports and contents that meet the precision requirements. Therefore, when establishing enterprise-level BIM application standards, it is crucial to thoroughly consider the requirements of design engineers regarding the types, content, and format of information. Moreover, top managers should actively support the BIM implementation, enhancing the legitimacy of the work content of engineering designers involved in BIM projects. They should also allocate the necessary technical and project resources to support BIM implementation. Concurrently, they should establish clear BIM application objectives. Architectural engineering design enterprises should adopt a project-based approach and establish the application goals of BIM at the initial stage of project development. These objectives should be as systematic and diverse as possible, and importantly, they should be measurable. This approach enhances the standardization and sustainability of BIM application in engineering design firms. Moreover, these managerial insights should be linked to sustainability goals. BIM can facilitate circular economy practices in China's construction sector, such as through material tracking, and reducing resistance can expedite this transition. Future policies might advocate for BIM as a tool to achieve net-zero carbon targets, thereby aligning digital and green transformations [59].

6. Conclusions

To explore the behavioral resistance to BIM implementation, this study integrates the status quo Bias (SQB) theory and the innovation diffusion theory and proposes a factor model for predicting the behavioral resistance of architectural engineering design engineers to BIM implementation. Following the development of a theoretical model grounded in the SQB framework, which encompasses nine hypothesized relationships pertaining to SQB predictors and innovation diffusion predictors, data were collected from a sample of 197 design engineers involved in BIM-based construction projects in China. The collected data were subsequently analyzed using PLS-SEM. The empirical study showed all the hypotheses were supported, and the results indicated that resistance to change toward BIM is the primary driving predictor behind behavioral resistance to BIM implementation. Status quo bias of design engineers toward existing work methods manifests as a tendency to resist BIM-related changes, which is the result of the combined effects of inertia, self-efficacy, and perceived distributive equity. Resistance to change poses a significant barrier to the successful adoption of BIM technology. Based on the data from the empirical analysis, inertia emerges as the primary factor driving resistance to change, followed by perceived distributive equity and self-efficacy. To proactively mitigate resistance, architectural design firms should reduce employees' reliance on traditional software and work practices, despite the challenge posed by inertia [60]. Inertia is a key contributor to resistance, as the more stubbornly employees rely on familiar work patterns and tools, the stronger their resistance to new technologies becomes. Employees' self-efficacy also influences their resistance to BIM technology. During the process of learning new BIM tools and adapting to new workflows, self-efficacy plays a critical role, with stronger self-efficacy enabling the development of more positive psychological cues and facilitating faster acceptance of change [61]. Perceived distributive equity has strong associates with resistance to change second only to inertia. As benefit-driven actors, employees are highly sensitive to evaluations of fairness following changes [62], including shifts in workload, compensation, and authority. From the employees' perspective, the fairer the perceived distribution, the weaker their resistance to BIM [63]. Resistance to change is the most critical factor driving employees' behaviors that ultimately lead to opposition against BIM implementation [64]. Employees' psychological resistance to change not only manifests in direct actions to resist BIM adoption but also influences their objective judgment. This can result in dissatisfaction

with the current BIM implementation environment and skepticism about whether BIM is compatible with existing work practices [65,66].

In summary, this study demonstrates that addressing behavioral resistance—by reducing inertia, strengthening self-efficacy, and ensuring fairness—is essential for achieving BIM’s potential for innovation and sustainable transformation in construction. Theoretically, our SQB integration offers a robust framework for explaining digital failure; practically, it calls for strategic policies and targeted training to accelerate BIM-driven change.

Nonetheless, this study has several limitations that should be addressed in future research. First, the use of cross-sectional data limits the ability to thoroughly examine causal relationships. Future studies should utilize longitudinal data collection methods to more effectively validate the causal links among variables. Additionally, incorporating AI-driven behavioral monitoring within BIM platforms could dynamically track resistance patterns, such as through sentiment analysis of user feedback, allowing for real-time interventions. Second, the structural model lacked control variables. Future research should investigate the effects of various control variables. Additionally, the sample was solely drawn from engineering design firms, which may restrict the theoretical framework’s applicability to other professionals within the construction industry. Subsequent studies should include participants from various sectors, like general contractors, to better understand the mechanisms of behavioral resistance to BIM implementation and assess the broader applicability of the findings. Thirdly, to address common method bias (CMV) and the context-dependence of Chinese construction firms, such as the influence of government policies that limit generalizability, conducting cross-cultural studies is recommended. These studies could compare resistance mechanisms in China with those in Western contexts, thereby revealing how institutional differences impact BIM adoption and addressing the regional limitation of our sample.

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