A Measurement Model of Trust in Construction Projects

Abstract

Purpose: Lack of trust in construction projects will lead to poor project performance or project failure, indicating the importance of trust-building. Existing studies have developed various trust models, while most studies covered limited trust factors, failed to clarify their meanings and relationships, or lacked qualitative or quantitative evidence. Thus, this study aims to develop a measurement model of trust in construction projects with theoretical justification as well as qualitative and quantitative data.

Design: A literature review was conducted to identify conceptual types, factors, and indicators of trust. Individual interviews and focus groups were performed to test the proposed framework with qualitative data. A survey and Confirmatory Factor Analysis (CFA) method were utilized to build the measurement model of trust using quantitative data in BIM-assisted projects.

Findings: The proposed trust framework covered the four conceptual types, four factors (integrity, competency, benevolence, and commitment), and 13 indicators, supported by the results of interviews and focus groups. The measurement model of trust from CFA results supported the significant, positive, and one-to-one relationships between 13 indicators and four factors of trust in BIM-assisted projects.

Originality: Theoretically, the study provides new insights into the multi-dimensional nature of trust. In practice, the findings could facilitate trustors and trustees to better understand, build, measure, and enhance trust in construction projects.

Key Words: Trust; Construction projects; Confirmatory Factor Analysis (CFA); Building Information Modeling (BIM).

Introduction

Trust is a critical facilitator of positive relationships between owners and contractors in construction projects (Cheung *et al.*, 2011; Zuppa, 2016). It has been identified as one enabler to facilitate collaboration and enhance productivity in construction projects (Deep *et al.*, 2021). Projects with a high level of trust can have lower costs, shorter time, and better project performance (Laan *et al.*, 2011; Wong *et al.*, 2005), while the lack of trust will cause low work efficiency and even project failure (Cerić *et al.*, 2021; Wu *et al.*, 2020). When setting up a contract, owners may prefer to specify as many details as possible and create bounds to constrain the contractors' behaviors (Ning *et al.*, 2019). Correspondingly, contractors may try to get more compensation to increase their own benefits (Laan *et al.*, 2011). During the construction phase, owners could conduct rigid and detailed control due to the suspicions of contractors' work (Karlsen *et al.*, 2008), while contractors may not have the incentives to increase work efficiency and quality (Rose and Manley, 2011). Considering the payment, retainage is an important part that owners would use to control contractors' behaviors (Larson, 1997). Contractors may frontload their billings to earn profits earlier (Jones, 2009). In addition, there are frequent conflicts and disputes about the project schedule, cost, quality, etc. (Hasanzadeh *et al.*, 2016). The lack of trust between contractors and owners forms an adversarial relationship (Chan, 2003), which is harmful to construction projects. Therefore, building trust is important in construction projects.

There is a lack of a commonly accepted definition of trust. Trust was defined as a psychological state showing people's intention to accept vulnerability considering the positive expectations of others (Jin, 2005; Laan *et al.*, 2011), while others argued that trust is also a behavioral term (Lewicki and Bunker, 1996; McKnight and Chervany, 2001). Also, some

researchers showed that trust is a sociological and cultural phenomenon containing both expectations and rational behaviors (Girmscheid and Brockmann, 2010; Koehn, 1996), while others indicated that trust is not only a simple expectation but also confidence when facing uncertain and risky environments (Bhattacharya, 1998; Lewicki and Bunker, 1996). The divergence of trust definitions may cause problems when connecting theoretical concepts to empirical findings (Watson, 2005).

In construction projects, the lack of a clear definition and framework of trust impacts trust-building (He *et al.*, 2022). It is necessary to expand contextual boundaries to provide a comprehensive definition of trust as well as a trust framework, which can support efficient project management (Lu *et al.*, 2023; Wong *et al.*, 2005). BIM-assisted projects have become a major part of construction projects. In North America, the BIM adoption rate is 74% for contractors (Salleh *et al.*, 2023). BIM enables participants to communicate with each other and manage projects more efficiently (Chen, 2013), while it requires a higher level of trust than traditional projects (Lee *et al.*, 2018). Good trust-based relationships facilitate the efficient integration and transmission of information using BIM (Ji and Orgun, 2006) and support successful project delivery (Lee and Chong, 2021; Mathews *et al.*, 2017). Thus, it is critical to build and measure trust in BIM-assisted projects (He *et al.*, 2022). Existing work has analyzed different conceptual types to define trust as affection, cognition, intention, or behavior, and has explained trust using models with different factors, such as integrity, competence, benevolence, and commitment (Cummings and Bromiley, 1996; Lewis and Weigert, 1985; McKnight and Chervany, 2001; Wong and Cheung, 2005). However, limited studies covered all conceptual types and factors and identified their relationships to understand and measure trust multi-dimensionally, especially with both qualitative and quantitative data. For BIM projects, existing

trust-based models (Farouk *et al.*, 2023; Lee *et al.*, 2018; Olugboyega and Windapo, 2019) also covered limited conceptual types and factors, failed to explain their relationships, or lacked qualitative or quantitative data.

To address the gaps, this paper aims to develop a measurement model of trust in construction projects based on literature review, qualitative data (interviews and focus groups), and quantitative data (surveys). First, different conceptual types, factors, indicators, and their relationships were reviewed to form a trust framework. Then, individual interviews and focus groups were conducted to test the proposed framework. Next, Confirmatory Factor Analysis (CFA) and survey data were utilized to build a measurement model of trust in BIM-assisted projects. The findings not only provide valuable insights into the multi-dimensional nature of trust relying on theoretical justifications as well as qualitative and quantitative evidence, but also guide practitioners to build and measure trust in construction projects.

Development of Trust Framework

Existing studies have explored trust frameworks. However, some covered limited conceptual types of trust; some failed to clarify the relationships between different conceptual types; some considered limited factors and indicators; some covered all four factors but lacked sufficient qualitative or quantitative evidence. Therefore, this literature review aims to propose a trust framework covering all conceptual types of trust, factors, indicators, and their relationships based on literature, which will be tested by qualitative and quantitative data.

Conceptual Types of Trust

Based on the human information processing theory, perception, cognition, and action are the three major stages in which people get information, analyze information, make decisions, and respond to the environment (Feng *et al.*, 2023; Proctor and Zandt, 2018). The trust-building

follows this theory to form four conceptual types of trust with a progressive relationship. The first type is affective trust, which refers to the emotional bond and attachment (Lewis and Weigert, 1985; Zhang *et al.*, 2024) and indicates how the trustor feels about the trustee (Cummings and Bromiley, 1996). It is from feeling and sense rather than reasoning and understanding (Wu *et al.*, 2017), which relates to the perception stage that the trustor knows the trustee without any further consideration. It is also defined as emotional trust (Lewis and Weigert, 1985), affective state (Cummings and Bromiley, 1996), and dispositional trust (McKnight and Chervany, 2001). Second, cognitive trust indicates trust based on knowledge and how the trustor rationally thinks about the trustee (Cummings and Bromiley, 1996; McAllister, 1995; Zhang *et al.*, 2024). It is grounded in the trustor's rational perception and assessment of the trustee (Lewis and Weigert, 1985; Wu *et al.*, 2017). This type relates to the cognition stage in which the trustor analyzes the information of the trustee. It is also called knowledge-based trust (Lewicki and Bunker, 1996) and cognition-based trust (Wong *et al.*, 2008). Third, intentional trust focuses on the trusting intentions that are determined by personal willingness (Cummings and Bromiley, 1996; McKnight and Chervany, 2001). This type of trust also links to the cognition stage about making trust decisions. It is also entitled to intended behavior (Cummings and Bromiley, 1996; Wang *et al.*, 2015) and trusting intentions (McKnight and Chervany, 2001). The last type is behavioral trust, which explains the trustor's trusting behavior (He *et al.*, 2022; Lewis and Weigert, 1985), relating to the action stage of undertaking the risk and performing trust action. It is also called behavioral trust (Lewis and Weigert, 1985) and trust-related behavior (McKnight and Chervany, 2001).

Even though there are discussions on different conceptual types of trust (as shown in Table 1), few studies addressed all four types of trust. McAllister (1995) and Wong et al. (2008)

only identified affective trust and cognitive trust. Lewis and Weigert (1985) identified cognitive, emotional, and behavioral trust, while intentional trust is missing. Cummings and Bromiley (1996) explored the affection, cognition, and intended behavior of organizational trust, without considering the behavioral dimension. Even though one study explored all four conceptual types (McKnight and Chervany, 2001), affective trust and cognitive trust were combined when discussing their relationships. In addition, Schilke *et al.* (2021) indicated that existing studies focused on affective trust, cognitive trust, and behaviors, while more research is needed to generalize various categorical trusts and explore the interrelationships between them considering both trustor's trust and trustee's trustworthiness. Therefore, there is a lack of studies discussing all four types of trust and their relationships, especially in the construction industry.

Table 1. Conceptual types of trust in previous studies

Reference	Affective trust	Cognitive trust	Intentional trust	Behavioral trust
Lewis and Weigert (1985)	Emotional trust: emotional bond among participants in the relationship	Cognitive trust: The trustor trusts people cognitively. The choice is based on "good reason" from information and judgment.		Behavioral trust: The trustor undertakes the risk and takes action because of the expectation that all persons will act competently and dutifully.
Cummings and Bromiley (1996)	Affective state: How does the trustor feel about the trustee?	Cognition: How does the trustor think about the trustee?	Intended behavior: What is the trustor's behavioral intent towards the trustee?	
McAllister (1995)	Affect-based trust: Emotional relations between individuals are the basis for trust.	Cognition-based trust: Available knowledge is one rational foundation for trust.		
McKnight and Chervany (2001)	Dispositional: the disposition to trust	Perceptual: trusting beliefs; Structural: institution-based trust	Intentional: trusting intentions	Behavioral: trust-related behavior

Wong et al. (2008)	Affect-based trust: emotional and sentimental bond	Cognition-based trust: cognitive bearings based on knowledge; System-based trust: focus on the procedure without considering personal issues

126 ***Factors and Indicators of Trust***

127 According to the four conceptual types, factors of trust have been discussed in existing

128 work, as shown in Table 2. Based on the literature review, four factors and corresponding

129 indicators were identified, as summarized in Table 3.

130 **Table 2.** Factors of trust in existing studies

References	Integrity	Competence	Benevolence	Commitment
Cummings and Bromiley (1996)	Negotiates honestly: The trustee is honest in interaction before commitments.		Avoids taking excessive advantage: The trustee does not take opportunistic advantage of another.	Keeps commitments: The trustee "makes good-faith efforts" to keep commitments.
Mayer et al. (1995)	Integrity: the perception of the trustor that the trustee adheres to a set of acceptable principles	Ability: the trustor's confidence in the competence of the trustee in certain domains	Benevolence: the trustor's perception that "a trustee wants to do good to the trustor"	
Lewicki and Bunker (1996)	Calculus-based trust: Parties are trusted to do what they say.		Identification-based trust: Parties are mutually trusted to act on behalf of each other and protect the other party's interests.	Knowledge-based trust: Parties know each other well enough that their behavior is predictable.
Akbar et al. (1998)	Reliability: The trustee "can be relied on to fulfill obligations".		Fairness: The trustee acts fairly when the opportunity is available.	Predictability: The trustee behaves "in a predictable manner".
McKnight and Chervany (2001)	Integrity: The trustee "makes good-faith agreements, tells the truth, and fulfills promises".	Competence: The trustee "has the ability or power to act as what one needs to be done".	Benevolence: The trustee "acts in one's interest rather than acting opportunistically".	Predictability: The trustee's "actions that are consistent to be forecasted in one given situation".

Hartman (2003)	Intuitive trust: the trustor's "emotional response and 'rapid processing' response"	Competence trust: the trustor's confidence in the trustee in performing a specific task	Integrity trust: the trustor's perception of the trustee's willingness to protect the interest of the trustor	
Cox (2009)	"Integrity": The trustee is "honest and ethical".	Ability/Capacity: The trustee has his abilities and capacities proved. Past experiences: The trustee has "past successes on similar projects" or the trustor has good experience with collaborative partners.	Intention: The trustee has "good intentions". Openness: The trustee is "willing to share information and openly communicate".	Risk: "The greater the overall project risk shared among the collaborators, the greater the reliance for our team members to perform their roles to eliminate the risk, and therefore our need for trust grows in order to reach the desired goals".

131 **Table 3.** Four factors and thirteen indicators of trust

Factors	Indicators	Definitions	References
Integrity	Honesty	The trustee makes good-faith agreements and tells the truth.	(McKnight and Chervany, 2001); (Rheu *et al.*, 2021); (Lansing *et al.*, 2023)
	Reliability	The trustee fulfills promises.	(McAllister, 1995); (Pinto *et al.*, 2009); (Lansing *et al.*, 2023)
	Ethics	The trustee serves the trustor in an ethical manner.	(Pinto *et al.*, 2009); (McKnight and Chervany, 2001)
Competency	Credential	The trustee has the evidence to show the past performance.	(Alzahrani *et al.*, 2017); (Messina *et al.*, 2014)
	Track record	How the trustee has carried out role-related duties in past projects.	(Pinto *et al.*, 2009); (McAllister, 1995)
	Ability	The trustee has the power to handle the task and deliver the desired outcomes.	(McKnight and Chervany, 2001); (Pinto *et al.*, 2009); (Farouk *et al.*, 2023); (Lansing *et al.*, 2023)
Benevolence	Good motives	The trustee wants to do good to the trustor.	(Pinto *et al.*, 2009); (McKnight and Chervany, 2001)
	Fairness	The trustee acts fairly when the opportunity is available.	(McAllister, 1995); (Hannah, 1991); (Yan and Zhang, 2020)
	Caring	The trustee cares about the trustor's interests.	(McAllister, 1995); (McKnight and Chervany, 2001)
	Openness	The trustee is willing to share information and communicate openly.	(Cox *et al.*, 2005); (Lansing *et al.*, 2023)

Commitment	Dedication	The trustee makes good-faith efforts.	(Pinto *et al.*, 2009); (Yan and Zhang, 2020)
	Predictability	The trustee's actions are consistent to be forecasted in the given situation.	(Hannah, 1991); (McKnight and Chervany, 2001)
	Taking responsibility	The trustee fulfills the responsibilities specified in the job description.	(McAllister, 1995)

The first factor is integrity, which relates to affective trust. It answers the question, "Does the relationship feel right?" (Hartman, 2003). The factor indicates the basic norms and principles of the trustee (Sagar *et al.*, 2023), which impacts the trustor's impression and emotional response towards the trustee without any evidence (Ruan *et al.*, 2017). Three indicators were identified to express integrity. Honesty indicates the sincere acts of telling the truth to the trustor (McKnight and Chervany, 2001), especially about their mistakes, inaccuracies, and vulnerability (Lansing *et al.*, 2023; Rheu *et al.*, 2021). Reliability refers to the expectation that the trustee will keep their promises (Pinto *et al.*, 2009; Vanhala *et al.*, 2016). Ethics is predominant in integrity (Cox, 2009), representing that the trustee should take an ethical manner during the cooperation (McKnight and Chervany, 2001). To sum up, integrity is the belief that the participants in the cooperation will behave honestly and reliably and adhere to ethics, principles, and standards (Lean *et al.*, 2009).

The second factor is competency, which relates to cognitive trust. It answers the question, "Can you do the job?" (Hartman, 2003). It means that the trustor is satisfied with the work of the trustee or added value created by the trustee in projects (Jiang *et al.*, 2016). It mainly relies on the reported information in other relationships or previous work (Johnson and Grayson, 2005). There are three indicators. Credential is the evidence supporting the reputation and performance of the trustee to enhance trust (Alzahrani *et al.*, 2017; Messina *et al.*, 2014). Track record shows the experience of the trustee in previous projects to judge competence (Hussain, 2018; Zhu and

Akhtar, 2014). Ability indicates the capability of the trustee to complete the tasks and to make contributions to the project's success (Oliveira *et al.*, 2017; Vanhala *et al.*, 2016), such as work with BIM (Farouk *et al.*, 2023), effective communication (Sagar *et al.*, 2023), and other relevant expertise (Lansing *et al.*, 2023).

The third factor is benevolence, which answers the question, "Will you look after my interests?" (Hartman, 2003). It relates to the intentional trust about whether the trustee will behave during the cooperation (Xie and Peng, 2009). It implies that the trustee has a positive intention toward the trustor during construction projects (Akbar *et al.*, 1998; Mayer *et al.*, 1995). Four indicators were identified. Good motives indicate the trustee's willingness to do good to the partner instead of hurting the trustor's benefits to earn their own profits (McKnight and Chervany, 2001; Pinto *et al.*, 2009; Sagar *et al.*, 2023). Fairness represents that the trustee will act fairly without succumbing to egocentric or opportunistic behavior (Oliveira *et al.*, 2017; Vanhala *et al.*, 2016). For example, the trustee is fair when negotiating the project contract (Yan and Zhang, 2020). Caring indicates the trustee will protect the trustor's interests and consider others' needs during the cooperation (McKnight and Chervany, 2001). Openness means that the trustee is willing to communicate and share information with the trustor openly (Cox, 2009; Lansing *et al.*, 2023).

The last factor is commitment, which answers the question, "Will you do your job as committed?" (Hartman, 2003). It is the factor relating to behavioral trust, which focuses on the trustee's commitment to achieving what they promise in construction projects (Pratt and Dirks, 2007). There are three indicators. Dedication indicates that the trustee makes good-faith efforts on the project (Cummings and Bromiley, 1996), representing the credibility of the trustee to contribute to the cooperation (Chang and Chou, 2011) and keep professional (Yan and Zhang,

2020). Predictability represents the predictable behaviors of the trustee during the cooperation (McKnight and Chervany, 2001), evaluating whether the trustee's actions are consistent enough according to previous records. Taking responsibility means the trustee feels responsible for the needs of others and is willing to respond to the needs in cooperation (McAllister, 1995).

Existing studies mainly accounted for limited factors of trust (Table 2). For example, Cummings and Bromiley (1996), Lewicki and Bunker (1996), and Akbar (1998) focused on integrity, benevolence, and commitment, while competency is missing. Mayer et al. (1995) addressed integrity, competence, and benevolence, but the commitment factor was not considered. Even though two studies explored all four factors (Cox, 2009; McKnight and Chervany, 2001), they lacked qualitative and quantitative data to test the framework.

Trust Framework and Hypotheses

Fig. 1 shows the trust framework combining four conceptual types, four factors, and 13 indicators discussed above. The development of the trustor's dispositions and behaviors toward the trustee can be explained as four stages: affection, cognition, intention, and behavior. The four conceptual types of trust can be categorized as affective trust, cognitive trust, intentional trust, and behavioral trust, which have a progressive relationship. The trustee's characteristic factors and indicators are the key elements influencing the trust-building process. Overall, the trustor will determine their dispositions and behavior based on the trustee's characteristics across four stages, which connects the conceptual types with factors and indicators. Therefore, trust can be defined as the willingness of a party/person to be affectively, cognitively, intentionally, and behaviorally vulnerable to another party/person grounded on integrity, competence, benevolence, and commitment of that party.

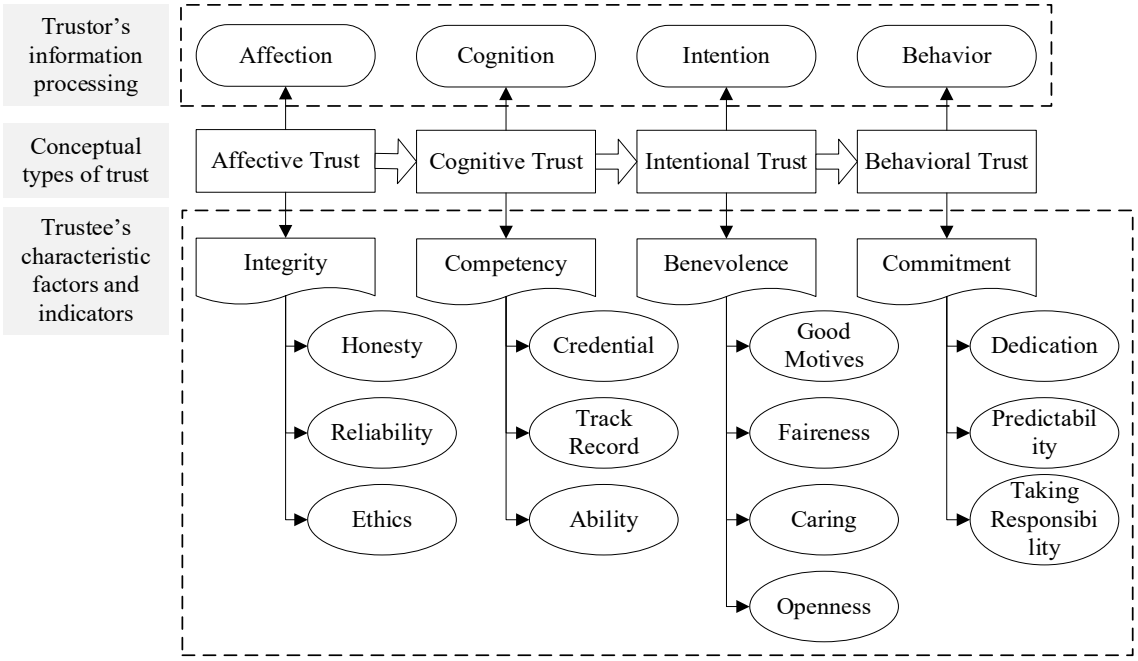

Fig. 1. Trust framework with four conceptual types and four factors

According to the proposed trust framework, a hypothesized measurement model was proposed (Fig. 2), covering four hypotheses. Hypothesis 1 (H1): All indicators of trust can be explained by the four factors. Hypothesis 2 (H2): Each indicator can be related to only one factor. The two hypotheses support the relationships between the four factors and 13 indicators. Hypothesis 3 (H3): Error terms associated with each indicator were uncorrelated. This hypothesis indicates that the indicators are not correlated with each other. Hypothesis 4 (H4): The four factors have inter-correlations with each other. The hypothesis supports the correlations between the four factors based on the four conceptual types of trust.

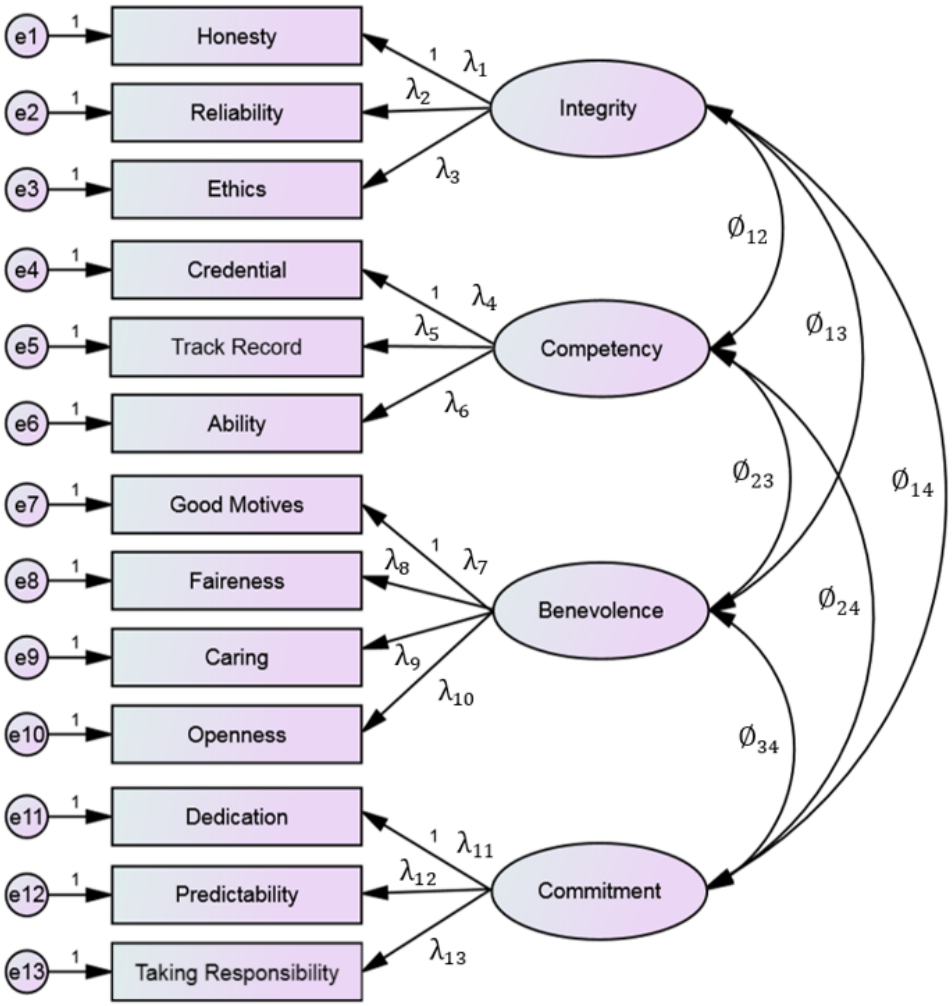

Fig. 2. The hypothesized measurement model of trust

Note: $\emptyset_{ij}$ is the path coefficient between each two of the four factors. λ_x indicates the regression coefficient between indicator x and its related factor.

Methodology

Research Framework

A mixed method was applied in this study, utilizing the strengths of both qualitative and quantitative methods (Creswell, 2017; Doyle *et al.*, 2009; Johnson and Onwuegbuzie, 2004). In particular, a sequential exploratory strategy was used, which involves qualitative data collection and analysis as the first phase to explore a phenomenon and quantitative data collection and analysis as the second phase to validate and interpret the findings within a chosen sample

(Creswell, 2017; Ivankova *et al.*, 2006). It is especially advantageous for building new frameworks and finding new instruments (Creswell, 2017). Mixed methods have been widely used in studies on framework development. For example, the frameworks of success factors of integrated project delivery on industrial construction projects (Wood *et al.*, 2024), key factors associated with workplace bullying and mental health of construction industry apprentices (Ross *et al.*, 2021), and critical factors in the development of assembled buildings in steel structure projects (Yu *et al.*, 2023) were developed using the sequential exploratory mixed methods.

Fig. 3 shows the research framework of this study. First, the trust framework was proposed based on a literature review, which is an effective way to start the trust framework (Costigan *et al.*, 1998; McKnight and Chervany, 2001). The proposed trust framework covered four conceptual types of trust, four factors, and 13 indicators as well as their relationships. Second, qualitative data was collected from nine interviews and two focus groups covering practitioners (i.e., participants working in the industry) and academicians (i.e., participants working in the academia) to explore the trust framework (the first phase of the sequential exploratory strategy). Seven-point Likert scales were used to rank the importance of trust and each factor; four open-ended questions were set to explore participants' opinions of trust in construction projects (Table 4). Third, based on the proposed framework and qualitative results, quantitative data was collected to validate the trust framework by developing a measurement model of trust in BIM-assisted projects (the second phase of the exploratory strategy). A web-based survey was applied to rate the factors and indicators in measuring trust in BIM-assisted projects using a seven-point Likert scale. Responses from 97 BIM academicians were analyzed using CFA. CFA aims to test how the measured indicators represent the factors in a theoretical model (Hair *et al.*, 2010), which has been commonly used in analyzing trust (Chow *et al.*, 2012;

Wong and Cheung, 2005; Wong *et al.*, 2008). Integrating qualitative and quantitative methods, the mixed research design could help better understand and measure trust.

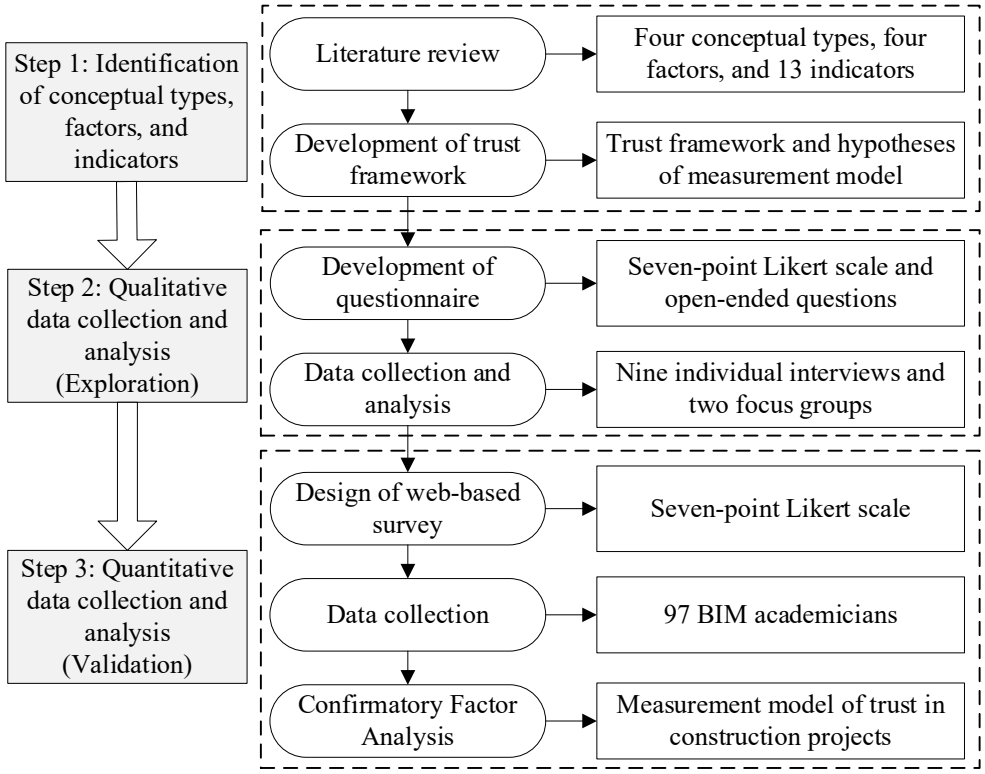

Fig. 3. Research framework

Table 4. List of questions for interviews and focus groups

No.	Questions
Q1	Do you think there is any trust in the construction business?
Q2	What is your definition of trust in the construction business?
Q3	Along a seven-point Likert scale, please rate the importance of trust for the success of a business.
Q4	From an owner's perspective, how do you determine whether a contractor is trustworthy or not?
Q5	Four factors were identified to measure trust based on a literature review, please rate the importance of each factor in measuring owners' trust of contractors along a seven-point Likert scale. • Integrity: the trustee adheres to a set of acceptable principles. • Competency: the ability of the trustee in certain domains. • Benevolence: the trustee wants to do good to the trustor. • Commitment: the trustee makes efforts to keep commitments.
Q6	Besides the above four factors, are there any other factors that should be considered?

Interviews and Focus Groups

Nine interviews were conducted with four practitioners and five academicians (Table 5). Four practitioners included subcontractors, construction managers, and consultants, with an

248 average 15-year working experience. Five academicians were faculties with an average 8-year
249 working experience in civil and construction-related departments. Moreover, two focus groups
250 were organized in Georgia. Five general contractors were included in the first focus group, with
251 an average 8-year working experience and working on 30 to 60 projects per year. Two virtual
252 design and construction managers participated in the second focus group, with an average 9-year
253 working experience and more than 170 construction projects on average.

254 **Table 5.** Demographic information of participants in interviews and focus groups

	Participants	Working years	State	Business Type/Position
Interviews	1	15	Georgia	Sub-contractor
	2	3	Georgia	Construction manager
	3	25	Georgia	Construction manager
	4	19	Georgia	Consultant
	5	9	Colorado	Associate professor
	6	5	South Carolina	Assistant professor
	7	N/A	Pennsylvania	Assistant professor
	8	12	Georgia	Associate professor
	9	7	California	Assistant professor
Focus group 1 (5 participants)		8 (average)	Georgia	General contractor
Focus group 2 (2 participants)		9 (average)	Georgia	Virtual design and construction manager

255 ***Confirmation Factor Analysis***

256 BIM academicians were selected as the target population due to their comprehensive
257 experiences in BIM-assisted projects and understanding of trust-related theories. A total of 137
258 responses were collected. If the participant did not have any BIM experience (i.e., working with
259 BIM in academia or industry), the response was discarded. 40 responses were removed due to
260 the incomplete information and disqualification of BIM experience. Finally, 97 responses were
261 used for further analysis. All respondents had working experience with BIM (average years =
262 4.38), supporting their sufficient understanding of trust in BIM-assisted projects.

263 Regarding demographic information (Table 6), 97 participants covered assistant professor
264 (21%), professor (20%), associate professor (16%), lecturer/instructor/senior lecturer (11%),

graduate students (9%), head/dean/director/etc. (6%), researcher (6%), and others (10%). Then, respondents came from various countries, including the USA (58%), UK (5%), China (4%), Australia (4%), India (3%), and others (26%, e.g., Turkey, New Zealand, Germany, etc.). Most participants had doctoral degrees (71%), followed by master's degrees (22%) and bachelor's degrees (7%). Moreover, participants showed an average of 13.28 years of academic experience. More importantly, most participants also had industrial experiences (85 out of 97). The average industrial experience was 9.28 years. Even though they were academicians, their industrial experiences could support them to provide responses considering the industry perspective. In addition, participants evaluated their confidence in construction management expertise as 5.39 out of 7 on average, and 5.02 out of 7 for BIM, supporting their confidence in evaluating trust in BIM-assisted projects.

Table 6. Demographic information of BIM academicians

Position/Title	**Number of participants**	**Country**	**Number of participants**	**Highest Degree**	**Number of participants**
Assistant professor	20	USA	56	Bachelor's degree	7
Associate professor	16	UK	5	Master's degree	21
Graduate student	9	Australia	4	Doctoral degree	69
Head/Dean/Director/etc.	6	China	4		
Lecturer/Instructor/Senior lecturer	11	India	3		
Professor	19	Others	25		
Researcher	6				
Others	10				
Average	13.28	9.28	5.39	5.02	4.38
Standard deviation	9.00	11.13	1.33	1.55	1.97

The 97 responses were screened for potential problems, including missing value, normality assumptions, and multi-collinearity, to prepare for data analysis (Chen *et al.*, 2014, 2016). 117 missing values from 9 participants were replaced by the mean values of corresponding indicators (Newman, 2014). The normality distribution assumption for each indicator was confirmed; no extreme collinearity was found, as shown in Table 7. The sample

size is sufficient for CFA (i.e., 5 times model parameters (Myers *et al.*, 2011)). Thus, the data was analyzed using CFA (SPSS AMOS software) to develop the measurement model.

Table 7. Normality and multi-collinearity tests

Tests	Indicators	Values from the responses
Normality distribution	Skewness index (*SI*)	-1.596 to 0.223 (recommended value: absolute value of 3 (Kline, 2015)
	Kurtosis index (*KI*)	-0.147 to 3.649 (recommended value: absolute value less than 10 (Kline, 2015)
Multi-collinearity	Bivariate correlation (*r*)	No less than 0.85 (Berry *et al.*, 1985)
	Squared multiple correlations ($R2SMC$)	No less than 0.9 (Hair *et al.*, 2010; Kline, 2015)
	Variance inflation factor (*VIF*)	No less than 10 (Hair *et al.*, 2010; Kline, 2015)

Results

Qualitative Results from Interviews and Focus Groups

All participants agreed "there is trust in the construction business". However, participants had different definitions of trust, such as "do what they say they will do", "believe in their commitment", "do what is right for the project and not be selfish", and "do their due diligence and watch out for others". Those definitions mainly covered intentional trust and behavioral trust, while affective trust and cognitive trust were missing. Moreover, all participants agreed that trust is extremely important for construction project success (mean score of 6.81 out of 7). Regarding whether a contractor is trustworthy or not, participants mentioned "good selection criteria", "prequalification with enough research", "track history and reference", "direct interaction", "good reputation", "transparency of contract" and "their ability to keep their word". These answers aligned with the competency and commitment factors, while integrity and benevolence factors were not included. Then, all four factors showed great importance in measuring trust (Table 8). Commitment (6.45 out of 7) was perceived as the most important factor, followed by integrity (6.27 out of 7), benevolence (6.00 out of 7), and competency (5.82 out of 7). For other factors that may influence trust in construction projects, most participants

could not think of others because the proposed factors are comprehensive. Only two participants provided other three factors: consistency, transparency, and longevity. Consistency should belong to the commitment factor, which measures whether the trustee can perform actions consistent with their commitments. Transparency can be incorporated into the benevolence and commitment factors, indicating the transparent process of conducting work to make sure the trustee is benevolent and finishes the tasks as promised. Longevity can be explained by the whole four-factor framework to form a virtuous circle of trust-building to maintain long-term trust. Therefore, the trust framework covering four types and four factors could explain and measure trust comprehensively.

Table 8. Importance level of four trust factors using seven-point Likert scale

Factors	Individual interviews									Focus groups		Mean values
	1	2	3	4	5	6	7	8	9	1	2	
Integrity	5	7	6	7	5	6	7	6	6	7	7	6.27
Competency	6	5	7	5	6	5	6	4	6	7	7	5.82
Benevolence	5	7	6	6	7	6	5	5	5	7	7	6.00
Commitment	6	7	6	6	6	7	7	7	5	7	7	6.45

Measurement Model of Trust

To evaluate the acceptability of the CFA results, the goodness-of-fit (GOF) was analyzed by five measures (as shown in Table 9). All indices fell into the recommended ranges, indicating that the measurement model fitted the data well.

Table 9. GOF measures of the trust measurement model

GOF Indices	Recommended value	Measurement model
Normed chi-square χ^2	≤ 3.00 (Chen *et al.*, 2014, 2016)	1.968
RMSEA	≤ 0.10 (Browne and Cudeck, 1993)	0.100
CFI	> 0.80 (Brown, 2014; Hair *et al.*, 2010)	0.950
TLI	> 0.80 (Brown, 2014; Hair *et al.*, 2010)	0.933
PNFI	≥ 0.50 (Hair *et al.*, 2010)	0.684

The standardized output and AMOS output of the measurement model are shown in Fig. 4 and Table 10. λ_x indicates the coefficient between indicator x and its related factor. $\emptyset_{ij}$ is the coefficient between each two factors. Larger coefficients represent stronger evidence to support

the correlations (Brown, 2014). The measurement model did not reveal any redundant factors, indicators, or contradictory relationships, which can measure trust by 13 indicators and four factors in BIM-assisted projects.

Table 10. AMOS output of the trust measurement model

Path	Symbol	Estimate	Standard estimation	Standard error	Critical ratio	P Label
Regression Weights						
Path from integrity to honesty	λ_1	1.000	0.929	-	-	-
Path from integrity to reliability	λ_2	0.911	0.926	0.058	15.802	***
Path from integrity to ethics	λ_3	1.032	0.880	0.075	13.786	***
Path from competency to credential	λ_4	1.000	0.796	-	-	-
Path from competency to track record	λ_5	0.740	0.737	0.097	7.638	***
Path from competency to ability	λ_6	1.045	0.900	0.109	9.547	***
Path from benevolence to good motives	λ_7	1.000	0.836	-	-	-
Path from benevolence to fairness	λ_8	1.133	0.899	0.099	11.442	***
Path from benevolence to caring	λ_9	1.225	0.894	0.108	11.335	***
Path from benevolence to openness	λ_{10}	1.207	0.896	0.106	11.378	***
Path from commitment to dedication	λ_{11}	1.000	0.874	-	-	-
Path from commitment to predictability	λ_{12}	1.040	0.817	0.103	10.090	***
Path from commitment to taking responsibility	λ_{13}	0.984	0.844	0.092	10.663	***
Covariances and correlations						
Covariance between integrity and competency	$\emptyset_{12}$	0.797	0.802	0.153	5.202	***
Covariance between integrity and benevolence	$\emptyset_{13}$	0.745	0.700	0.149	5.010	***
Covariance between integrity and commitment	$\emptyset_{14}$	0.816	0.735	0.157	5.204	***
Covariance between competency and benevolence	$\emptyset_{23}$	0.589	0.635	0.134	4.396	***
Covariance between competency and commitment	$\emptyset_{24}$	0.726	0.750	0.149	4.869	***
Covariance between benevolence and commitment	$\emptyset_{34}$	0.891	0.860	0.164	5.445	***

Note: *** indicates $p < 0.001$.

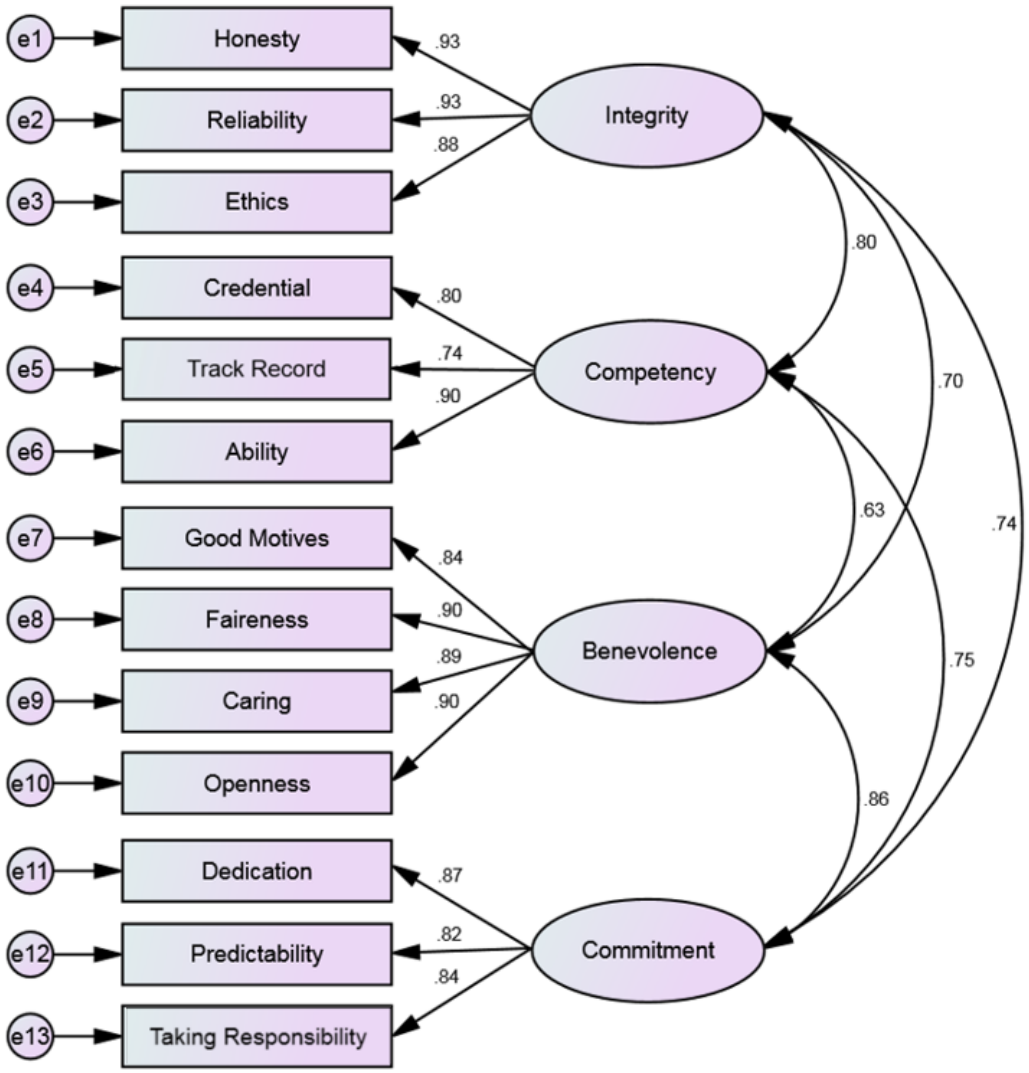

Fig. 4. The standardized measurement model of trust

All four hypotheses were verified through the results. H1 and H2 were verified through λ_i. As all λ_i estimations were higher than 0.7 (Hair *et al.*, 2010) and significant ($P < 0.001$) in the expected positive direction, H1 was accepted, showing the four factors can explain all 13 indicators of trust in BIM-assisted projects. Also, each indicator only loaded on one factor, supporting the acceptance of H2. For the integrity factor, honesty and reliability were the most important indicators ($\lambda_1 = \lambda_2 = 0.93$); ethics also showed great importance ($\lambda_3 = 0.88$). For the competency factor, ability was the most critical indicator ($\lambda_6 = 0.90$), while credential and track record showed lower importance ($\lambda_4 = 0.80, \lambda_5 = 0.75$). For the benevolence factor, fairness,

caring, and openness almost showed the same importance ($\lambda_8 = \lambda_{10} = 0.90, \lambda_9 = 0.89$), while good motivation had lower importance ($\lambda_7 = 0.84$). For commitment factor, dedication, predictability, and taking responsibility had close importance ($\lambda_{11} = 0.87, \lambda_{12} = 0.82, \lambda_{13} = 0.84$). Then, H3 was accepted because the standard errors were between 0.06 and 0.17, which is acceptable (Byrne, 2013), supporting the construct validity of this measurement model. Finally, H4 was supported by $\emptyset_{ij}$. The four factors had significant relations with each other because all estimations of $\emptyset_{ij}$ were significant ($P < 0.001$) and exceeded 0.32 (Billings and Wroten, 1978). In particular, benevolence and commitment factors had the closest relationship ($\emptyset_{34} = 0.86$); integrity and competency also showed a close correlation ($\emptyset_{12} = 0.80$).

Discussion

This study proposed a measurement model of trust in construction projects, especially BIM-assisted projects, based on four conceptual types, four factors, and 13 indicators, supported by theoretical justification, qualitative evidence, and quantitative data. Some key findings were discussed below, including trust definition and trust factors in construction projects, quantitative relationships between trust factors (i.e., integrity, competency, benevolence, and commitment) in BIM-assisted projects, and potential application of the trust framework.

One important finding is that when no information was provided, experts could not define and measure trust comprehensively. They only identified the two “tangible” factors (i.e., competency and commitment) measuring the trustee’s past experiences and skills as well as the behaviors, while the two "intangible” factors (i.e., integrity and benevolence) relating to affective trust and intentional trust were ignored. However, following the four-factor trust framework, they recognized the importance of integrity and benevolence factors. It emphasizes the importance of applying a trust framework in understanding and measuring trust

multidimensionally in construction projects as well as supports the comprehensiveness of the proposed framework. It is consistent with a previous study emphasizing the importance of a comprehensive trust framework to ensure project performance (Lu *et al.*, 2023).

Another key finding is that all four trust factors are important in construction projects. Existing work shows that it is difficult to develop trust among multi-disciplinary stakeholders in BIM-related projects (Cheng *et al.*, 2023), emphasizing the importance of considering various trust factors. Commitment is the most important factor, indicating that behavioral trust is the last but most critical part of the trust-building process in construction projects. According to the dedication, predictability, and taking responsibility indicators, the trustee should show great efforts on the projects (e.g., exploring innovative methods to improve the project performance (Jalali *et al.*, 2023)), keep consistent actions during the cooperation (e.g., sending out the billings based on actual progress), and fulfill their responsibilities listed in the contract (e.g., enhancing contract governance and knowledge sharing to support project work (Shang *et al.*, 2023)). Integrity was ranked as the second factor, which is the beginning stage of trust-building. It emphasizes that the trustee should keep the basic norms (i.e., honesty, reliability, and ethics) to develop a strong emotional connection with the trustor. For example, when owners believe that contractors will tell the truth, keep promises, and avoid unethical actions (e.g., using unqualified materials), affective trust can be developed. Benevolence was ranked as the third factor. Good motives, fairness, caring, and openness of the trustee can support the trustor's intentional trust. For example, contractors should always be willing to protect the owners' benefits, not take any opportunistic behaviors that may compromise the project performance, care about the owners' needs during the cooperation, and communicate with owners openly and promptly from the beginning (Francisco and Rabechini, 2019). Competency factor was ranked the last. The trustee

should show credential, track record, and ability of similar projects to justify that they are qualified for the work, such as previous experience, certificates, professional skills, etc. (Charles *et al.*, 2022). In addition, the rank emphasizes that the deficiency of competency can be marked up by strong integrity, benevolence, and commitment. In the project-driven construction industry, which has dynamic uncertainties and high complexities (Laan *et al.*, 2011), trust relies heavily on the trustee's inherent characteristics, not just professional skills and experience (not entirely rational) (Schilke *et al.*, 2021).

In BIM-assisted projects, the relationships between trust factors were quantified. Benevolence and commitment factors had the strongest relationship. In the four-stage trust-building process, forming trust intentions and behaviors are closely related. Having the trust intention is usually the former step of taking trust behavior. To enhance trust in BIM-assisted projects, the trustee should pay attention to improving the benevolence and commitment together. For example, when communicating the information with owners openly and considering owners' benefits utilizing BIM, contractors should also show their dedication and responsibility in completing tasks. Also, integrity and competency factors showed a close relationship. After forming the affective trust based on the trustees' basic norms, the trustor will further explore more information to build cognitive trust, such as BIM-related credentials, project experiences, and qualifications. Previous studies indicated that expertise and knowledge related to BIM are important in trust-building in BIM-based construction projects (Farouk *et al.*, 2023). The trustee needs to improve integrity and competency together, such as showing their honesty, reliability, and ethics when communicating with the trustor as well as preparing documents to support their credentials, past records, and abilities. During the process,

communication technology and systems can be applied to enhance cooperation (Charles *et al.*, 2022; Lee *et al.*, 2022).

Practitioners and academicians can apply the trust framework and measurement model to understand, build, and measure multi-dimensional trust in construction projects. Theoretically, the framework provides new insights into the multidimensional nature of trust, helping academicians analyze trust and related factors systematically and comprehensively. In practice, the trustor can apply the indicators to evaluate the trustee from the four aspects effectively, facilitating the scientific trust-building process. Meanwhile, the measurement model can assist the trustee to improve themselves to enhance trust within the cooperation, such as showing their integrity to form a great initial impression, preparing sufficient documents to show competency, improving benevolence by caring about owners' benefits, developing open communication strategies, and keeping commitment by performing consistent actions and being responsible for the project tasks.

Conclusions

Trust is essential for developing positive relationships in construction projects to support project success, while the lack of trust will cause a vicious circle that harms the project performance. To better understand and build trust in construction projects, this study develops a measurement model of trust based on theoretical justification as well as qualitative and quantitative data. Through a literature review, a trust framework covering four conceptual types of trust, four factors, and 13 indicators was proposed. Results of individual interviews and focus groups supported the proposed framework and showed the rank of four factors (i.e., commitment, integrity, benevolence, and competency). Finally, a measurement model of trust was developed in BIM-assisted projects using survey data. The 13 indicators had positive, single,

and significant relations with the four factors to measure trust comprehensively. All four factors had significant inter-correlations with each other to form the multi-dimensional trust. Specifically, integrity and competency had a close relationship, while benevolence and commitment showed a close correlation. The trust framework and measurement model provide a comprehensive understanding of multi-dimensional trust in construction projects. Practically, the findings can help practitioners to better understand, build, and measure trust in construction projects. However, there are three major limitations. First, the practitioners all came from Georgia, indicating the potential limitation due to the lack of diversity in areas. Future work should cover different areas, companies, and positions to further test the trust framework. Second, even though most of the BIM academicians had industrial experiences, no practitioners were included in the survey to develop the measurement model. Future studies should include practitioners to test the model. Third, the measurement model was only tested in BIM-assisted projects, even though BIM was applied in a major part of construction projects. Future work should investigate other construction projects to expand the application of the model.

References

Akbar, Z., Bill, M. and Vincenzo, P. (1998), "Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance", *Organization Science*, Vol. 9 No. 2, pp. 141–159, doi: 10.1287/orsc.9.2.141.

Alzahrani, L., Al-Karaghouli, W. and Weerakkody, V. (2017), "Analysing the critical factors influencing trust in e-government adoption from citizens' perspective: A systematic review and a conceptual framework", *International Business Review*, Vol. 26 No. 1, pp. 164–175, doi: https://doi.org/10.1016/j.ibusrev.2016.06.004.

Berry, W.D., Feldman, S. and Stanley Feldman, D. (1985), *Multiple Regression in Practice*, Sage.

Bhattacharya, R. (1998), "A Formal Model of Trust based on Outcomes", *Academy of Management Review*, Vol. 23 No. 3, pp. 459–473, doi: 10.5465/AMR.1998.926621.

Billings, R.S. and Wroten, S.P. (1978), "Use of path analysis in industrial/organizational psychology: Criticisms and suggestions", *Journal of Applied Psychology*, Vol. 63 No. 6, pp. 677–688, doi: 10.1037/0021-9010.63.6.677.

Brown, T.A. (2014), *Confirmatory Factor Analysis for Applied Research*, Guilford Publications.

Browne, M.W. and Cudeck, R. (1993), "Alternative ways of assessing model fit", *Sociological Methods & Research*, Vol. 21 No. 2, pp. 230–258. doi: 10.1177/0049124192021002005

Byrne, B.M. (2013), *Structural Equation Modeling with AMOS: Basic Concepts, Applications and Programming*, Routledge.

Cerić, A., Vukomanović, M., Ivić, I. and Kolarić, S. (2021), "Trust in megaprojects: A comprehensive literature review of research trends", *International Journal of Project Management*, Vol. 39 No. 4, pp. 325–338, doi: 10.1016/j.ijproman.2020.10.007.

Chan, A.P.C. (2003), "Partnering in Construction: Critical Study of Problems for Implementation", *Journal of Management in Engineering*, Vol. 19 No. 3, pp. 126–136, doi: 10.1061/(ASCE)0742-597X(2003)19:3(126).

Chang, S.-C. and Chou, C.-M. (2011), "Factors affecting users online shopping behavior: Integrating the constraint-based and dedication-based relationship perspectives", *African Journal of Business Management*, Vol. 5 No. 2, pp. 370–382. doi: 10.5897/AJBM10.323.

Charles, S.H., Chang-Richards, A. and Yiu, (Kenneth) Tak Wing. (2022), "New success factors for construction projects: a systematic review of post-2004 literature", *Construction Innovation*, Vol. 22 No. 4, pp. 891–914, doi: 10.1108/CI-02-2021-0030.

Chen, Y. (2013), *Measurement Models of Building Information Modeling Maturity*, Purdue University.

Chen, Y., Dib, H., Cox, R.F., Shaurette, M. and Vorvoreanu, M. (2016), "Structural equation model of building information modeling maturity", *Journal of Construction Engineering and Management*, Vol. 142 No. 9, p. 4016032. doi: 10.1061/(ASCE)CO.1943-7862.0001147

Chen, Y., Dib, H. and F. Cox, R. (2014), "A measurement model of building information modelling maturity", *Construction Innovation*, Vol. 14 No. 2, pp. 186–209. doi: 10.1108/CI-11-2012-0060

Cheng, J., Huang, L., Jiang, L., Chen, J., Chen, W. and He, Y. (2023), "Fostering Knowledge Collaboration in Construction Projects: The Role of BIM Application", *Buildings*, Vol. 13 No. 3, p. 812, doi: 10.3390/buildings13030812.

Cheung, S.O., Wong, W.K., Yiu, T.W. and Pang, H.Y. (2011), "Developing a trust inventory for construction contracting", *International Journal of Project Management*, Vol. 29 No. 2, pp. 184–196, doi: https://doi.org/10.1016/j.ijproman.2010.02.007.

Chow, P.T., Cheung, S.O. and Chan, K.Y. (2012), "Trust-building in construction contracting: Mechanism and expectation", *International Journal of Project Management*, Vol. 30 No. 8, pp. 927–937, doi: https://doi.org/10.1016/j.ijproman.2012.03.002.

Costigan, R.D., Iiter, S.S. and Berman, J.J. (1998), "A Multi-Dimensional Study of Trust in Organizations", *Journal of Managerial Issues*, Vol. 10 No. 3, pp. 303–317. https://www.jstor.org/stable/40604201

Cox, R.F. (2009), "Key Elements to Successful International Collaboration in Construction Project Delivery", *International Conference on Construction and Real Estate Management*, Beijing, China.

Cox, R.F., Issa, R.R.A. and Koblegard, K. (2005), "Management's Perception of Key Behavioral Indicators for Construction", *Journal of Construction Engineering and Management*, Vol. 131 No. 3, pp. 368–376, doi: 10.1061//asce/0733-9364/2005/131:3/368.

Creswell, J.W. (2017), *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Sage Publications.

Cummings, L.L. and Bromiley, P. (1996), "The organizational trust inventory (OTI)", *Trust in Organizations: Frontiers of Theory and Research*, Vol. 302 No. 330, pp. 39–52. doi: 10.4135/9781452243610.n15

Deep, S., Gajendran, T. and Jefferies, M. (2021), "A systematic review of 'enablers of collaboration' among the participants in construction projects", *International Journal of Construction Management*, Taylor and Francis Ltd., Vol. 21 No. 9, pp. 919–931, doi: 10.1080/15623599.2019.1596624.

Doyle, L., Brady, A.-M. and Byrne, G. (2009), "An overview of mixed methods research", *Journal of Research in Nursing*, Vol. 14 No. 2, pp. 175–185, doi: 10.1177/1744987108093962.

Farouk, A.M., Zulhisham, A.Z., Lee, Y.S., Rajabi, M.S. and Rahman, R.A. (2023), "Factors, Challenges and Strategies of Trust in BIM-Based Construction Projects: A Case Study in Malaysia", *Infrastructures*, Vol. 8 No. 1, p. 13, doi: 10.3390/infrastructures8010013.

Feng, Y., Chen, Y., Zhang, J., Tian, C., Ren, R., Han, T. and Proctor, R.W. (2023), "Human-centred design of next generation transportation infrastructure with connected and automated vehicles: a system-of-systems perspective", *Theoretical Issues in Ergonomics Science*, pp. 1–29, doi: 10.1080/1463922X.2023.2182003.

Francisco, G. and Rabechini Jr, R. (2019), "Stakeholder management influence on trust in a project: A quantitative study", *International Journal of Project Management*, Elsevier Ltd, APM and IPMA, Vol. 37 No. 1, pp. 131–144, doi: 10.1016/j.ijproman.2018.11.001.

Girmscheid, G. and Brockmann, C. (2010), "Inter- and intraorganizational trust in international construction joint ventures", *Journal of Construction Engineering and Management*, Vol. 136 No. 3, pp. 353–360, doi: 10.1061/(ASCE)CO.1943-7862.0000142.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. and Tatham, R.L. (2010), *Multivariate Data Analysis*, *Pearson Prentice Hall. New Jersey. Humans: Critique and Reformulation. Journal of Abnormal Psychology*, 7th edition, Vol. 87, Pearson Prentice Hall.

Hannah, L.C. (1991), *The conditions of trust in the construction industry and their relevance to project success*, Clemson University.

Hartman, F. (2003), *Ten Commandments of Better Contracting: A Practical Guide to Adding Value to an Enterprise Through More Effective SMART Contracting*, edited by Hartman, F.

Hasanzadeh, S., Gad, G.M., Nasrollahi, S., Esmaeili, B. and Gransberg, D.D. (2016), "Impacts of Levels of Trust on Dispute Occurrences in Highway Projects", *Construction Research Congress 2016*, Reston, VA: American Society of Civil Engineers, Reston, VA, doi: 10.1061/9780784479827.051.

He, X., Tim, B. and Selçuk, Ç.M. (2022), "Towards a theoretical framework of trust in BIM-enabled collaboration", *2022 European Conference on Computing in Construction*, Ixia, Rhodes, Greece.

Hussain, S. (2018), "Contradictory results on the mediating roles of two dimensions of trust between transformational leadership and employee outcomes", *Journal of Organizational Effectiveness: People and Performance*, Vol. 5 No. 1, pp. 39–63, doi: 10.1108/JOEPP-11-2016-0063.

Ivankova, N. V., Creswell, J.W. and Stick, S.L. (2006), "Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice", *Field Methods*, Vol. 18 No. 1, pp. 3–20, doi: 10.1177/1525822X05282260.

Jalali, A., Jaafar, M., Abdelsalam Al Rfoa, S.K. and Abhari, S. (2023), "The indirect effect of high-performance work practices on employees' performance through trust in management", *Journal of Facilities Management*, Vol. 21 No. 2, pp. 242–259, doi: 10.1108/JFM-07-2021-0073.

Ji, M. and Orgun, M.A. (2006), "Trust management and trust theory revision", *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, Vol. 36 No. 3, pp. 451–460, doi: 10.1109/TSMCA.2006.871628.

551 Jiang, W., Lu, Y. and Le, Y. (2016), "Trust and Project Success: A Twofold Perspective between
552 Owners and Contractors", *Journal of Management in Engineering*, Vol. 32 No. 6, p.
553 4016022, doi: 10.1061/(ASCE)ME.1943-5479.0000469.

554 Jin, X. (2005), "Model for Fostering Trust and Building Relationships in China's Construction
555 Industry", *Journal of Construction Engineering & Management*, American Society of Civil
556 Engineers, doi: 10.1061/(ASCE)0733-9364(2005)131:11(1224).

557 Johnson, D. and Grayson, K. (2005), "Cognitive and affective trust in service relationships",
558 *Journal of Business Research*, Vol. 58 No. 4, pp. 500–507, doi: 10.1016/S0148-
559 2963(03)00140-1.

560 Johnson, R.B. and Onwuegbuzie, A.J. (2004), "Mixed Methods Research: A Research Paradigm
561 Whose Time Has Come", *Educational Researcher*, Vol. 33 No. 7, pp. 14–26, doi:
562 10.3102/0013189X033007014.

563 Jones, M.W. (2009), "An analysis of the impact of information systems on the level of trust in
564 the construction industry", ScholarWorks, Walden University.

565 Karlsen, J., Graee, K. and Massaoud, M. (2008), "Building trust in project-stakeholder
566 relationships", *Baltic Journal of Management*, Vol. 3 No. 1, pp. 7–22, doi:
567 10.1108/17465260810844239.

568 Kline, R.B. (2015), *Principles and Practice of Structural Equation Modeling*, Guilford
569 publications.

570 Koehn, D. (1996), "Should we trust in trust?", *American Business Law Journal*, Vol. 34 No. 2,
571 pp. 183–204, doi: 10.1111/j.1744-1714.1996.tb00695.x.

572 Laan, A., Noorderhaven, N., Voordijk, H. and Dewulf, G. (2011), "Building trust in construction
573 partnering projects: An exploratory case-study", *Journal of Purchasing and Supply*
574 *Management*, Vol. 17 No. 2, pp. 98–108, doi: https://doi.org/10.1016/j.pursup.2010.11.001.

575 Lansing, A.E., Romero, N.J., Siantz, E., Silva, V., Center, K., Casteel, D. and Gilmer, T. (2023),
576 "Building trust: Leadership reflections on community empowerment and engagement in a
577 large urban initiative", *BMC Public Health*, BioMed Central Ltd, Vol. 23 No. 1, p. 1252,
578 doi: 10.1186/s12889-023-15860-z.

579 Larson, D.W. (1997), "Trust and Missed Opportunities in International Relations", *Political*
580 *Psychology*, Vol. 18 No. 3, pp. 701–734, doi: 10.1111/0162-895X.00075.

581 Lean, O.K., Zailani, S., Ramayah, T. and Fernando, Y. (2009), "Factors influencing intention to
582 use e-government services among citizens in Malaysia", *International Journal of*
583 *Information Management*, Vol. 29 No. 6, pp. 458–475, doi:
584 https://doi.org/10.1016/j.ijinfomgt.2009.03.012.

585 Lee, C.-Y. and Chong, H.-Y. (2021), "Influence of Prior Ties on Trust and Contract Functions
586 for BIM-Enabled EPC Megaproject Performance", *Journal of Construction Engineering*
587 *and Management*, American Society of Civil Engineers (ASCE), Vol. 147 No. 7, doi:
588 10.1061/(ASCE)CO.1943-7862.0002076.

589 Lee, C.-Y., Chong, H.-Y., Tanko, B.L. and Klufallah, M. (2022), "Effect between Trust in
590 Communication Technology and Interorganizational Trust in BIM-Enabled Projects",
591 *Journal of Construction Engineering and Management*, Vol. 148 No. 8, doi:
592 10.1061/(ASCE)CO.1943-7862.0002299.

593 Lee, C.Y., Chong, H.-Y. and Wang, X. (2018), "Enhancing BIM Performance in EPC Projects
594 through Integrative Trust-Based Functional Contracting Model", *Journal of Construction*
595 *Engineering and Management*, Vol. 144 No. 7, p. 6018002, doi:
596 doi:10.1061/(ASCE)CO.1943-7862.0001521.

597 Lewicki, R.J. and Bunker, B.B. (1996), "Developing and maintaining trust in work
598 relationships", *Trust in Organizations: Frontiers of Theory and Research*, Sage
599 Publications.

600 Lewis, J. and Weigert, A. (1985), "Trust as a Social Reality", *Social Forces*, Vol. 63 No. 4, p.
601 967, doi: 10.1093/sf/63.4.967.

602 Lu, W., Wu, L. and Zhao, R. (2023), "Rebuilding trust in the construction industry: a
603 blockchain-based deployment framework", *International Journal of Construction*
604 *Management*, Taylor & Francis, Vol. 23 No. 8, pp. 1405–1416, doi:
605 10.1080/15623599.2021.1974683.

606 Mathews, M., Robles, D. and Bowe, B. (2017), "BIM+ blockchain: A solution to the trust
607 problem in collaboration?", *CITA BIM Gathering 2017*, doi: 10.21427/D73N5K

608 Mayer, R.C., Davis, J.H. and Schoorman, F.D. (1995), "An Integrative Model of Organizational
609 Trust", *The Academy of Management Review*, Vol. 20 No. 3, pp. 709–734, doi:
610 10.2307/258792.

611 McAllister, D.J. (1995), "Affect- and Cognition-Based Trust as Foundations for Interpersonal
612 Cooperation in Organizations", *Academy of Management Journal*, Vol. 38 No. 1, pp. 24–
613 59, doi: 10.5465/256727.

614 McKnight, D. and Chervany, N. (2001), "Trust and Distrust Definitions: One Bite at a Time",
615 *Trust in Cyber-Societies Integrating the Human and Artificial Perspectives*, Vol. 2246, pp.
616 27–54, doi: 10.1007/3-540-45547-7_3.

Messina, F., Pappalardo, G., Rosaci, D., Santoro, C. and Sarné, G.M.L. (2014), "A Trust Model for Competitive Cloud Federations", *2014 Eighth International Conference on Complex, Intelligent and Software Intensive Systems*, pp. 469–474, doi: 10.1109/CISIS.2014.67.

Myers, N.D., Ahn, S. and Jin, Y. (2011), "Sample size and power estimates for a confirmatory factor analytic model in exercise and sport: a monte carlo approach", *Research Quarterly for Exercise and Sport*, Vol. 82 No. 3, pp. 412–423, doi: 10.1080/02701367.2011.10599773.

Newman, D.A. (2014), "Missing data: Five practical guidelines", *Organizational Research Methods*, Vol. 17 No. 4, pp. 372–411. doi: 10.1177/1094428114548590

Ning, Y., Feng, M., Feng, J. and Liu, X. (2019), "Understanding clients' experience of trust and distrust in dwelling fit-out projects", *Engineering, Construction and Architectural Management*, Vol. 26 No. 3, pp. 444–461, doi: 10.1108/ECAM-03-2018-0115.

Oliveira, T., Alhinho, M., Rita, P. and Dhillon, G. (2017), "Modelling and testing consumer trust dimensions in e-commerce", *Computers in Human Behavior*, Vol. 71, pp. 153–164, doi: https://doi.org/10.1016/j.chb.2017.01.050.

Olugboyega, O. and Windapo, A. (2019), "Theoretical model of trust-based relationships in building information modelling supply chain for construction projects", *Acta Structilia*, Vol. 26 No. 2, pp. 107–141, doi: 10.18820/24150487/as26i2.4.

Pinto, J.K., Slevin, D.P. and English, B. (2009), "Trust in projects: An empirical assessment of owner/contractor relationships", *International Journal of Project Management*, Vol. 27 No. 6, pp. 638–648, doi: https://doi.org/10.1016/j.ijproman.2008.09.010.

Pratt, M.G. and Dirks, K.T. (2007), "Rebuilding Trust and Restoring Positive Relationships: A Commitment-Based View of Trust", *Exploring Positive Relationships at Work: Building a Theoretical and Research Foundation.*, Lawrence Erlbaum Associates Publishers.

Proctor, R.W. and Zandt, T. Van. (2018), *Human Factors in Simple and Complex Systems*, CRC Press, Taylor & Francis Group.

Rheu, M., Shin, J.Y., Peng, W. and Huh-Yoo, J. (2021), "Systematic Review: Trust-Building Factors and Implications for Conversational Agent Design", *International Journal of Human–Computer Interaction*, Taylor & Francis, Vol. 37 No. 1, pp. 81–96, doi: 10.1080/10447318.2020.1807710.

Rose, T. and Manley, K. (2011), "Motivation toward financial incentive goals on construction projects", *Journal of Business Research*, Vol. 64 No. 7, pp. 765–773, doi: 10.1016/j.jbusres.2010.07.003.

650 Ross, V., Mathieu, S.L., Wardhani, R., Gullestrup, J. and Kõlves, K. (2021), "Factors Associated
651 With Workplace Bullying and the Mental Health of Construction Industry Apprentices: A
652 Mixed Methods Study", *Frontiers in Psychiatry*, Frontiers Media S.A., Vol. 12, doi:
653 10.3389/fpsyt.2021.629262.

654 Ruan, Y., Zhang, P., Alfantoukh, L. and Durresi, A. (2017), "Measurement Theory-Based Trust
655 Management Framework for Online Social Communities", *ACM Trans. Internet Technol.*,
656 Vol. 17 No. 2, pp. 1–24, doi: 10.1145/3015771.

657 Sagar, S.K., Oladinrin, O.T., Arif, M. and Rana, M.Q. (2023), "Interpretive structural model of
658 trust factors in construction virtual project teams", *Construction Innovation*, Emerald
659 Publishing, Vol. 23 No. 1, pp. 248–264, doi: 10.1108/CI-09-2021-0179.

660 Salleh, H., Ahmad, A.A., Abdul-Samad, Z., Alaloul, W.S. and Ismail, A.S. (2023), "BIM
661 Application in Construction Projects: Quantifying Intangible Benefits", *Buildings*, Vol. 13
662 No. 6, p. 1469, doi: 10.3390/buildings13061469.

663 Schilke, O., Reimann, M. and Cook, K.S. (2021), "Trust in Social Relations", *Annual Review of*
664 *Sociology*, Vol. 47 No. 1, pp. 239–259, doi: 10.1146/annurev-soc-082120-082850.

665 Shang, K., Wu, J. and Cao, Y. (2023), "Study on the Impact of Trust and Contract Governance
666 on Project Management Performance in the Whole Process Consulting Project—Based on
667 the SEM and fsQCA Methods", *Buildings*, Vol. 13 No. 12, p. 3006, doi:
668 10.3390/buildings13123006.

669 Vanhala, M., Heilmann, P. and Salminen, H. (2016), "Organizational Trust Dimensions as
670 Antecedents of Organizational Commitment", *Knowledge and Process Management*, Vol.
671 23 No. 1, pp. 46–61, doi: 10.1002/kpm.1497.

672 Wang, S.W., Ngamsiriudom, W. and Hsieh, C.-H. (2015), "Trust disposition, trust antecedents,
673 trust, and behavioral intention", *The Service Industries Journal*, Vol. 35 No. 10, pp. 555–
674 572, doi: 10.1080/02642069.2015.1047827.

675 Watson, M.L. (2005), "Can there be just one trust? A cross-disciplinary identification of trust
676 definitions and measurement", *The Institute for Public Relations*, pp. 1–25.

677 Wong, P.S., Cheung, S.O. and Ho, P.K. (2005), "Contractor as trust initiator in construction
678 partnering-prisoner's dilemma perspective", *Journal of Construction Engineering and*
679 *Management*, Vol. 131 No. 10, p. 1045. doi: 10.1061/(ASCE)0733-
680 9364(2005)131:10(1045)

681 Wong, P.S.P. and Cheung, S.O. (2005), "Structural Equation Model of Trust and Partnering
682 Success", *Journal of Management in Engineering*, Vol. 21 No. 2, pp. 70–80, doi:
683 doi:10.1061/(ASCE)0742-597X(2005)21:2(70).

Wong, W.K., Cheung, S.O., Yiu, T.W. and Pang, H.Y. (2008), "A framework for trust in construction contracting", *International Journal of Project Management*, Vol. 26 No. 8, pp. 821–829, doi: https://doi.org/10.1016/j.ijproman.2007.11.004.

Wood, X., Ghimire, P., Kim, S., Barutha, P. and Jeong, H.D. (2024), "Framework for Evaluating the Success of Integrated Project Delivery in the Industrial Construction Sector: A Mixed Methods Approach & Machine Learning Application", *Construction Economics and Building*, University of Technology, Sydney (UTS), Vol. 24 No. 1/2, doi: 10.5130/AJCEB.v24i1/2.8783.

Wu, G., Li, H., Wu, C. and Hu, Z. (2020), "How different strengths of ties impact project performance in megaprojects: the mediating role of trust", *International Journal of Managing Projects in Business*, Vol. 13 No. 4, pp. 889–912, doi: 10.1108/IJMPB-09-2019-0220.

Wu, G., Zhao, X. and Zuo, J. (2017), "Relationship between project's added value and the Trust--conflict interaction among project teams.(Report)(Author abstract)", *Journal of Management in Engineering*, Vol. 33 No. 4, pp. 4017011–4017009), doi: 10.1061/(ASCE)ME.1943-5479.0000525.

Xie, Y. and Peng, S. (2009), "How to repair customer trust after negative publicity: The roles of competence, integrity, benevolence, and forgiveness", *Psychology and Marketing*, Vol. 26 No. 7, pp. 572–589, doi: 10.1002/mar.20289.

Yan, L. and Zhang, L. (2020), "Interplay of Contractual Governance and Trust in Improving Construction Project Performance: Dynamic Perspective", *Journal of Management in Engineering*, Vol. 36 No. 4, pp. 1–12, doi: 10.1061/(ASCE)ME.1943-5479.0000791.

Yu, J., Chan, A., Wang, B., Liu, Y. and Wang, J. (2023), "A mixed-methods study of the critical success factors in the development of assembled buildings in steel structure projects in China", *International Journal of Construction Management*, Taylor and Francis Ltd., Vol. 23 No. 13, pp. 2288–2297, doi: 10.1080/15623599.2022.2052429.

Zhang, L., Anjum, M.A. and Wang, Y. (2024), "The Impact of Trust-Building Mechanisms on Purchase Intention towards Metaverse Shopping: The Moderating Role of Age", *International Journal of Human–Computer Interaction*, Taylor and Francis Ltd., Vol. 40 No. 12, pp. 3185–3203, doi: 10.1080/10447318.2023.2184594.

Zhu, Y. and Akhtar, S. (2014), "How transformational leadership influences follower helping behavior: The role of trust and prosocial motivation", *Journal of Organizational Behavior*, Vol. 35 No. 3, pp. 373–392, doi: 10.1002/job.1884.

Zuppa, D. (2016), "Perceptions of trust in the US construction industry", *Engineering, Construction and Architectural Management*, Vol. 23 No. 2, pp. 211–236, doi: 10.1108/ECAM-05-2015-0081.