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ENHANCING SUSTAINABILITY THROUGH THE INTEGRATION OF RELATIONAL CONTRACTING ELEMENTS IN BIM CONTRACTUAL FRAMEWORK FOR THE MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract

Construction projects involve a myriad of parties with distinct roles that often result in fragmentation, coordination challenges and adversarial relationships. The emergence of Building Information Modelling (BIM) has been regarded as one of the driving forces for integration and collaboration among project stakeholders. Nevertheless, the additional contractual risks brought by BIM may undermine its benefits, as the failure to address these risks could potentially lead to more disputes. Given that construction projects fundamentally rely on contracts to govern stakeholders' relationships, the present study aims to promote social sustainability in BIM-based construction by incorporating relational contracting elements (RCE) into BIM Protocol context, which in this study refers to a supplementary contractual arrangement used to govern BIM-related roles, responsibilities and risk allocation. Using data gathered from a research survey conducted among industry players in Malaysia and analysed through factor analysis, the study identified sixteen (16) significant BIM contractual risks that need to be addressed, and twenty-five (25) factors grouped under three (3) relational contracting elements (RCEs) that should be considered in BIM-enabled contractual arrangements. The findings are expected to contribute towards embedding sustainability in BIM-based construction projects in Malaysia.

Keywords: Building Information Modelling (BIM), contractual risks, sustainability, construction contract, construction management

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INTRODUCTION

Building Information Modelling (BIM) is a collaborative process that provides an information-rich digital representation of the physical and functional characteristics of a construction project throughout its entire life cycle. Besides technical benefits such as visualisation, cost and time reduction, and early error detection, BIM also fosters an innovative and integrated working environment that can boost the social sustainability of the construction industry (Elimualim & Gilder, 2014). The adoption of BIM able to transform the traditionally fragmented approach in construction management towards a greater collaborative and coordinated environment among the project participants. In Malaysia, BIM has been promoted through various national policies and strategic initiatives such as the Construction Industry Transformation Programme (CITP) 2016-2020, the Twelfth Malaysia Plan 2021–2025 (12MP), the Public Works Department (JKR) Strategic Plan 2021–2025, and the National Construction Policy 2030 (NCP 2030), all of which emphasise digitalisation and technology integration in the construction sector. BIM implementation is expected to be further strengthened under the upcoming Thirteenth Malaysia Plan (13MP) as part of Malaysia's long-term digital transformation agenda for the construction industry.

Although BIM has the potential to improve social sustainability among the contractual parties, it also exposes the stakeholders to contractual and legal risks that may adversely impact business performance and working relationships. Various studies have examined BIM-related contractual risks (Winfield, 2015; Habib et al. 2020; Baharom et al., 2021) which emphasise the criticality for the risks to be addressed in order to attain the full potential of BIM implementation. These concerns are further reinforced by recent research, such as Mohammadi et al. (2024), who examines critical risks and mitigation strategies in BIM contract documentation; and Alotaibi et al. (2024) who analyses the regulatory and legal implications of BIM adoption within contractual frameworks.

In order to address the risks, some researchers recommend the adoption of collaborative procurement methods, such as alliance contracting and integrated project delivery (IPD), both of which embed relational contracting principles (Holzer, 2015; Abd Jamil & Fathi, 2019). However, many BIM-based construction projects still adopt conventional non-collaborative procurement approaches due to industry familiarity and risk aversion (Holzer, 2015; Baharom et al., 2021; Ndwandwe et al., 2024). Therefore, a more pragmatic alternative is required to integrate relational elements into the existing contractual arrangements without necessitating a complete transformation of procurement systems. Furthermore, while countries such as the United Kingdom and the United States utilise BIM Protocols as supplementary contractual documents to support BIM-enabled project delivery, the extent to which relational contracting elements are embedded within these BIM Protocols remains unclear.

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Relational contracting is a governance approach that emphasises the management of long-term working relationships rather than relying solely on rigid contractual provisions (Macneil, 1980; Nwajei, 2021). It promotes collaboration through behavioural principles such as trust, commitment, cooperation and shared problem-solving, which complement traditional contract mechanisms (Rahman & Kumaraswamy, 2008). In the context of construction projects, Relational contracting elements (RCEs) refer to measurable components that operationalise such principles within contractual practices, ensuring coordinated decision-making, mutual accountability and equitable risk allocation among project participants (Liu et al., 2022). These elements strengthen social interaction and reduce adversarial behaviour, making them particularly relevant in BIM-enabled projects where multi-party collaboration and interdependency are critical for project success. Incorporating RCEs into BIM-related contractual arrangements may therefore address behavioural and coordination issues that are not adequately governed by conventional contract clauses alone.

Therefore, this study was conducted using a quantitative questionnaire survey and aims to: (1) identify the critical BIM contractual risks that need to be addressed, and; (2) to determine the key relational contracting elements (RCEs) that support the integration of relational contracting factors (RCFs) into BIM-enabled contractual arrangements. The findings of this study are expected to provide insights for integrating relational principles into BIM-related contractual practices and enhancing social sustainability in BIM-based construction projects.

LITERATURE REVIEW

BIM and Relational Contracting

The execution of tasks in a BIM environment differs from conventional working process, as BIM requires a higher level of cooperation and collaboration among project stakeholders. A greater degree of information sharing among the stakeholders is necessary to ensure seamless integration of data through the use of cloud platforms and BIM models. However, as various proprietary data are continuously incorporated and exchanged during the development of BIM models, such practices may compromise the data security and reliability, intellectual property rights (IPR), liability in cases of damaged or corrupted data, and data infringement risks (Brelih & Klinc, 2025). Furthermore, the unclear additional roles and obligations of stakeholders in a BIM environment, such as the role of a BIM Information Manager, can lead to disputes if parties resist the perceived liabilities and risks associated with these added responsibilities, thereby leading to antagonistic behaviour (Alwash, et al., 2017). Although this phenomenon remains underexplored, unresolved contractual risks and ambiguities are widely recognised as factors that may trigger disputes in BIM-based projects (Dalir et al., 2025)

Working with BIM also raises issues related to the doctrine of privity of contract, which stipulates that only parties who are legally bound by a contract can be granted rights or subjected to obligations (Ya'acob et al., 2018). In most construction contracts, designers cannot be held liable by contractors or sub-contractors, as they are not contractually bound to one another. This position conflicts with the collaborative nature of BIM, where project team members rely on each other's contributions via a shared model, thus creating a horizontal privity between contractors and design professionals. However, under the strict application of the doctrine, if an error occurs due to a designer's fault, parties such as the contractor or the quantity surveyor are not entitled to be compensated as there is no contractual relationship exist between them, even though in reality they depend on one another to complete the work. This situation may limit collaboration in BIM-based projects as working relationships are challenged by trust and liability concerns.

Recognising the implications of BIM on contractual relationships among project participants, countries such as the United Kingdom and the United States have introduced various technical guidelines and contractual supplements to support BIM implementation. However, the extent to which these documents adequately address privity-related issues and contractual risks remains underexplored. In the Malaysian context, several national BIM-related documents have been published (as shown in Table 1), however, the CIDB BIM Guide and Public Works Department (PWD) BIM Requirements have been criticised for failing to adequately address key contractual risks, particularly those related to data security, liabilities and legal responsibilities among project stakeholders (Alwee, et al., 2021; Raja Berema, 2021).

Table 1: Published BIM documents in the USA, the UK and Malaysia

Document Type	**Countries**		
	USA	**UK**	**Malaysia**
BIM Contract Guidelines	1. C106–2013 Digital Data Licensing Agreement 2. E203–2013 BIM and Digital Data Exhibit	1. CIC BIM Protocol (2013) (superseded) 2. UK BIM Framework Information Protocol (2022	N/A

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Document Type	Countries		
	USA	UK	Malaysia
BIM National Technical Standards	1. The National BIM Standard-United States (NBIMS) Version 3 (2015). 2. The National BIM Standard-United States (NBIMS) Version 4 – Project BIM Requirements (2021-2022).	1. PAS 1192 Series (superseded) 2. BS EN ISO 19650 Series (Parts 1-5)	1. PWD BIM Requirements for Design and Build Projects 2016 2. MyBIM Guide Series CIDB
Best Practice Guides	1. National BIM Guide for Owners by NBIMS, 2. BIM Implementation: An Owner's Guide to Getting Started by The Construction Users Roundtable 3. Penn State BIM Project Execution Planning Guide (2022)	1. UK BIM Framework – Guidance Series (Parts 1-8, updated quarterly) 2. Government Soft Landings (Updated 2022)	1. CIDB BIM Guide 2. MyBIM Adoption Strategy 3. PWD BIM Guidelines, Standards and Manual Working Process

Therefore, effective BIM implementation in the construction industry requires relational contracting elements (RCEs), such as communication, cooperation and transparency, to be embedded within contractual arrangements (Panteli et al., 2020; Al-Ashmori et al., 2022; Liu et al., 2022). Relational contracting procurement methods, such as alliancing, partnering and join-venture, have the potential to shift contractual relationships from a purely transactional approach towards more collaborative engagements (Nwajei, 2021). However, a complete transition to relational procurement is unlikely to occur in the near future, as conventional forms such as design–bid–build (DBB) and design–and–build (D&B) remain dominant in industry practice. Hence, integrating RCEs into existing BIM-enabled contractual arrangements offers a more pragmatic governance alternative to address BIM-related contractual risks.

The theoretical foundation for RCEs is grounded in Relational Contract Theory (RCT), which views contracts not solely as legal instruments but as frameworks that shape long-term working relationships (Macneil, 1980). From this perspective, adversarial behaviour in construction can be reduced when contractual relationships incorporate behavioural norms such as reciprocity, flexibility and mutual trust (Rahman & Kumaraswamy, 2008). In the BIM context, where project delivery is highly interdependent and data-driven collaboration is required, RCEs enable cooperative decision-making, joint risk management and improved accountability among contracting parties (Nwajei, 2021; Liu et al., 2022). Accordingly, this study identifies the critical RCE factors needed to strengthen relational governance in BIM-based construction contracts.

RESEARCH METHODOLOGY

This study employed quantitative survey approach using a structured questionnaire distributed among construction professionals involved in BIM-based projects. Purposive sampling was adopted as the exact population size of BIM practitioners in Malaysia is unknown and the study requires respondents with adequate knowledge and experience in BIM. The aim of the survey is to identify significant BIM contractual risks and determine the key Relational Contracting Factors (RCFs) that support the integration of Relational Contracting Elements (RCEs) into BIM-enabled contractual arrangements to address these risks.

A total of 17 BIM contractual risks and 34 RCFs were initially identified from an extensive review of past studies on BIM contract governance and relational contracting (Panteli et al., 2020; Baharom et al., 2021; Liu et al., 2022). These items were used to develop the questionnaire. A total of 147 valid responses were obtained from construction professionals with BIM experience using purposive sampling, which is appropriate for studies requiring expert judgement and specialised knowledge (Etikan, 2016). The data were analysed using three statistical techniques: the Relative Importance Index (RII) was used to rank BIM contractual risks and RCFs according to their perceived significance; Exploratory Factor Analysis (EFA) was conducted to identify the underlying RCF components; and Confirmatory Factor Analysis (CFA) was employed to validate the measurement structure. Reliability and sampling adequacy were confirmed using Cronbach's alpha and the Kaiser–Meyer–Olkin (KMO) test prior to factor analysis.

RII was used to rank the BIM contractual risks and RCFs according to their relative importance using the following formula:

$$\mathbf{RII = \Sigma W / (A*N)}$$

where W is the weight assigned to each factor on a 5-point Likert scale, A is the highest possible weight, and N is the total number of respondents. The following relevant levels were assigned: high (H) ($0.8 \leq$ RII ≤ 1); high-medium (H-M) ($0.6 \leq$ RII ≤ 0.8); medium (M) ($0.4 \leq$ RII ≤ 0.6); medium-low (M-L) ($0.2 \leq$ RII ≤ 0.4); and low (L) ($0 \leq$ RII ≤ 0.2) (Chen, et al., 2010). Subsequently, EFA was conducted to identify the underlying structure of the RCFs and to reduce variables into meaningful components. In this regard, several recommended tests were done to aid the development of the proposed EFA model. As EFA alone

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does not confirm the stability of the factor structure, CFA was then performed to validate the measurement model (Costello & Osborne, 2005). CFA complements EFA as it is a theory-testing model that offers a more practical method that can confirm the factorial validity of the EFA models (Yong & Pearce, 2013). The questionnaire consisted of three sections: Section A collected demographic information, Section B assessed 17 BIM contractual risks, and Section C measured 34 relational contracting factors (RCFs).

RESULTS AND DISCUSSION

A total of 147 responses were received from architects, engineers, quantity surveyors and other construction professionals involved in BIM-based projects. The reliability of the sample is supported by the fact that 88% of the respondents have more than five years of BIM project experience. The RII results for BIM contractual risks and RCFs are presented in Table 2 and Table 3, respectively.

Table 2: The RII for each category of BIM contractual risks

BIM Risk ID	BIM Contractual Risks	Relative Important Index	Overall Ranking	Importance Level
Information Management				
IM1	Fragmented and poorly coordinated information flow	0.782	1	H-M
IM3	Ambiguity in sharing information procedures	0.755	2	H-M
IM2	Lack of clarity on the role, responsibilities and liabilities of a BIM Information Manager	0.754	3	H-M
IM4	Contractual document prevalence	0.739	4	H-M
Liability				
LB1	Undefined roles and responsibilities of contractual parties	0.720	5	H-M
LB4	Loss and corruption of project data	0.701	7	H-M
LB2	Unclear liability for data amendments and modifications	0.699	8	H-M
LB3	Lack of clarity on the expected duty of care	0.693	10	H-M
LB5	Restrictions arising from the doctrine of privity of contract	0.667	14	H-M
Data Reliance				
DR2	Interoperability issues	0.713	6	H-M
DR3	Unclear procedures for data changes	0.699	9	H-M
DR1	Limited data reliance	0.661	15	H-M
Data Security				
DS2	Ambiguity in data access rights	0.683	11	H-M
DS3	Unclear data security procedures	0.683	12	H-M

BIM Risk ID	BIM Contractual Risks	Relative Important Index	Overall Ranking	Importance Level
DS1	Breach/compromise data confidentiality	0.678	13	H-M
Intellectual Property				
IP1	Data infringement	0.654	16	H-M
IP2	Uncertainty ownership/copyright of data	0.642	17	H-M

Table 3: The RII for each category of RCFs

RCE ID	Relational Contracting Factors	Relative Important Index	Overall Ranking	Importance level
Communication				
CM4	Clearly defined information sharing procedures	0.856	1	H
CM6	Well-established procedures for data and information changes	0.848	3	H
CM3	Use of similar/compatible BIM software packages and version	0.827	10	H
CM5	Equal access to project information	0.790	20	H-M
CM1	Compromise on unclear issues in construction contract	0.788	21	H-M
CM2	Co-location of different organisations	0.725	26	H-M
Commitment				
CT2	The requirement for parties to practice role integrity in fulfilling duties	0.849	2	H
CT1	Active participation in discussions	0.839	6	H
Coordination				
CR2	Clear working structure	0.845	4	H
CR3	Clear tasks procedures	0.839	5	H
CR7	Early involvement of all parties	0.834	8	H
CR4	Pre-construction planning structure	0.833	9	H
CR5	Method statement in coordination with site team	0.811	13	H
CR1	Practical relational work plan	0.810	14	H
CR6	Quality-enhancement plan	0.792	19	H-M
Cooperation				
CO2	Joint problem-solving	0.838	7	H
CO3	Early involvement of top management from various parties	0.824	11	H
CO1	Joint decision-making	0.810	14	H
CO4	Resource sharing	0.804	17	H
Transparency				

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RCE ID	Relational Contracting Factors	Relative Important Index	Overall Ranking	Importance level
TC3	Well-defined reporting method	0.833	9	H
TC1	Clear definition of roles, responsibilities and limitation of power	0.833	9	H
TC2	Comprehensive payment and claim procedures, mechanisms, terms and structures	0.800	18	H
Mutual Trust				
MT1	Training for collaboration knowledge and skills	0.815	12	H
MT2	Risk management workshop	0.807	15	H
MT3	Early warning systems to allow proactive risk allocation and mitigation	0.790	20	H-M
MT4	Contractual solidarity	0.770	23	H-M
Common Objectives				
CB1	Joint-declaration statement of achieving mutual objectives	0.805	16	H
CB3	Pre-agreed performance appraisal mechanism	0.777	22	H-M
CB2	Early partnership by establishing start up workshop	0.376	28	M-L
Flexibility				
FB1	Contract adjustment for unforeseen circumstances	0.788	21	H-M
Win-win principle				
WP2	Pain and gain sharing mechanism	0.752	24	H-M
WP4	Practicing liability waivers provision	0.735	25	H-M
WP3	Efficient conflict resolution	0.416	27	M
WP1	Incentives and bonuses for achieving agreed goals	0.272	29	M-L

As presented in Table 2, all 17 BIM contractual risks were perceived as having high to medium importance levels with RII values ranging from 0.642 to 0.782. Similarly, 91% of the RCFs were rated within high to medium importance level (see Table 3). Three RCFs recorded RII values below 0.5, namely *"efficient conflict resolution" (WP3), "early partnership by establishing start up workshop (CB2)"* and *"incentives and bonuses for achieving agreed goals" (WP1).* As these factors fell below the acceptable threshold, they were excluded from further analysis, leaving 31 RCFs for subsequent testing. Subsequently, EFA tests were performed on 17 BIM contractual risks and the 31 RCFs using principal component analysis (PCA) with oblique-rotation. As presented in Table 4, all KMO and factor loading values were acceptable except for the determinant value. However, as only one test parameter was marginally below the recommended level, the analysis proceeded with all items to avoid premature elimination of variables (Habing, 2003).

Table 4: Results of EFA for BIM Contractual Risks and Relational Contracting Factors

EFA Assessments and Applied Test	Recommended value	Value acquired	
		BIM contractual risks	RCFs
Factor Rotation Method using Component Correlation Matrix	> 0.32, it requires an oblique-rotation	>0.32, thus oblique-rotation	>0.32, thus oblique-rotation
Determinant Factor based on Correlation Matrix's Determinant	> 0.00001	1.75E-008	9.975E-15
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	KMO index ranges from 0 to 1, with ≥ 0.50 considered suitable for factor analysis	0.936	0.945
Bartlett's Test of Sphericity	Should be significant (p<.05) for factor analysis to be suitable.	0.000	0.000
Anti-Image Correlation Matrix	Diagonal value >0.5	>0.5	>0.5
Communalities	0.40-0.70	Range between 0.63 to 0.809	Range from 0.497 to 0.859
Cumulative Percentage of Variance and Eigenvalue	50%-60% and eigenvalue > 1	64.585%	56.586%

Subsequently, the remaining BIM contractual risks and RCFs underwent a factor refinement process following sequential steps recommended by Maskey et al. (2018): (1) the factor loading cut-off value is 0.40; (2) remove cross loading items with ratio exceeding 75% and retained if it is the opposite while removing the smaller coefficient, and; (3) each factor should consist of at least two items. As a result, one BIM contractual risk (LB3) and six RCFs (CM1, CO4, TC2, CB3, CM3 and FB1) were removed, leaving 16 BIM contractual risks and 25 RCFs for further analysis using CFA.

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The preliminary results of the CFA show that both of the BIM contractual risks and RCFs are not fit as they do not fulfil the acceptable fit indices of the chi-square, Goodness-Of-Fit Index (GFI), Adjusted Goodness-Of Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Standardized Root Mean Residual (SRMR) (see Table 5). According to Hooper et al. (2008) and Schreiber et al. (2006), model modification is acceptable to improve model fit, provided it is conducted cautiously and guided by statistical and theoretical justification. Accordingly, model refinement was carried out based on: (1) elimination of low factor loadings (< 0.50); (2) correlation of error terms within the same construct; and (3) removal of items with Standardised Residuals (SR) above ±2.58. Although not all absolute and incremental fit indices were achieved, at least one acceptable index from each fit category was satisfied, which is considered adequate for model acceptance (Brown, 2006). Therefore, the modified models in Figure 1 and Figure 2 were considered to demonstrate acceptable construct validity and model fit.

Table 5: Results of Preliminary Analysis and Modified Analysis of CFA

Fit statistic		**Cut-off Criteria**	**Preliminary analysis**		**Modified analysis**	
			BIM Contractual Risks	RCF	BIM Contractual Risks	RCF
Chi-square		<5	3.573	2.913	3.102	2.260
Absolute fit	GFI	When N > 100, researchers may choose a GFI cut-off value of .93	.762	.696	.796	.762
	AGFI	> .95	.686	.637	.728	.709
	RMSEA	<0.08 is tolerable, <0.05 is good, 0.05-0.08 is acceptable, 0.08-0.1 is marginal, >1 is poor	.133	.114	.117	.093
Incremental fit	CFI	>0.9 (Stevens, 1996) or >0.95	.882	.848	.909	.902
	NFI		.844	.787	.870	.838
	TLI		.862	0.832	.892	.889
SMSR		When N> 100, < .08 is preferred	.0527	.0547	.0564	.0504

The two-factor model of BIM contractual risks and the three-factor model of RCFs were subsequently subjected to construct validity assessment, as presented in Table 6. The results indicate that the two-factor model of BIM contractual risks demonstrated adequate convergent validity, meeting the threshold value of Average Variance Extracted (AVE ≥ 0.50) and Composite Reliability (CR ≥ 0.70). For the RCFs, one of the three relational contracting factors recorded an AVE value below 0.50; however, the construct was retained as its CR value exceeded 0.70 and its AVE was above 0.40, which is considered acceptable in social science research (Lam, 2012; Sharif et al., 2018). Moreover, the discriminant validity for both CFA models was established, as the AVE values for both constructs exceeded the Shared Variance (SV) values (Fornell & Larcker, 1981).

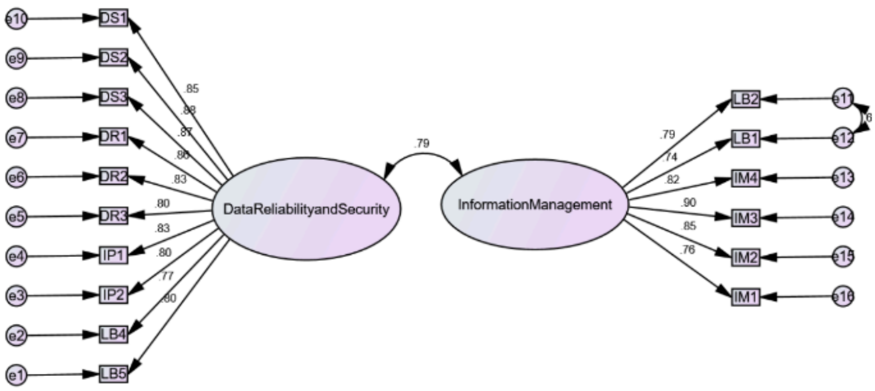

Figure 1: CFA Model for BIM Contractual Risks

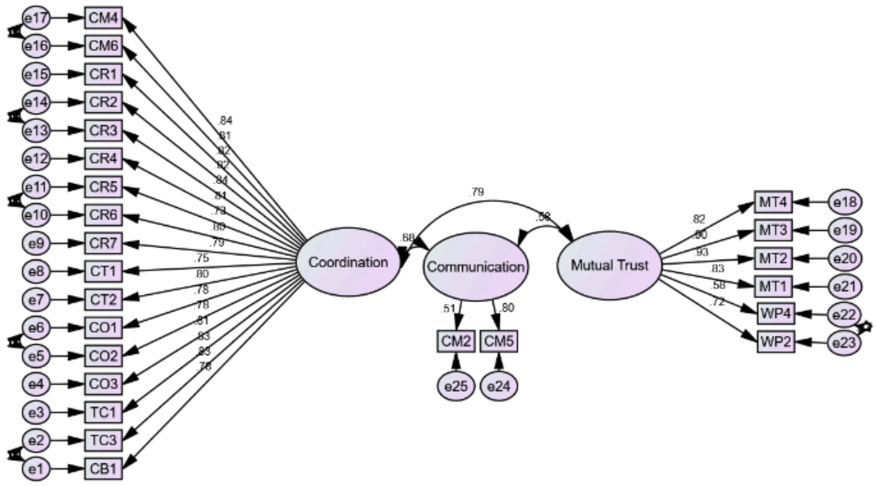

Figure 2: CFA Model of Relational Contracting Elements

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Table 6: Results of Validity and Reliability Tests

Type of Construct validity	Recommended tests	Recommended cut-off value	Factors	Value acquired	
				BIM contractual risks	RCFs
Convergent Validity	Average Variance Extracted (AVE)	0.5 (Fornell & Larcker, 1981)	Factor A	0.69	0.64
			Factor B	0.66	0.65
			Factor C	-	0.45
	Construct Reliabilities (CRs)	0.6 (Fornell & Larcker, 1981)	Factor A	0.9	1.0
			Factor B	0.9	0.9
			Factor C	-	0.6
Discriminant validity	Shared Variances (SV)			0.63	0.62

Hence, the two-factor model of BIM contractual risks and three-factor model of RCFs are deemed acceptable. The identified latent factors for BIM contractual risks are "*data reliability and security*" and "*information management"* with each risk having high regression weights, ranging between 0.76 to 0.90 which reflects significant results. As for the three-factor RCFs model, there are three important relational contracting elements (RCEs) identified, namely *"coordination", "communication"* and *"mutual trust"*. All factors in these categories consist of high regression weights except for "*co-location of different organisations"* (CM2). Table 7 presents the significant BIM contractual risks, RCEs and RCFs identified through this study.

Table 7: The identified significant BIM contractual risks, RCEs and RCFs

BIM Contractual Risks	
Data Reliability and Security	Loss and corruption of project data (LB4); Restrictions arising from the doctrine of privity of contract (LB5); Data infringement (IP1); Uncertainty ownership/copyright of data (IP2); Breach/compromise data confidentiality (DS1); Ambiguity in data access rights (DS2); Unclear data security procedures (DS3); Limited data reliance (DR1); Interoperability issues (DR2); Unclear procedures for data changes (DR3).

BIM Contractual Risks	
Information management	Fragmented and poorly coordinated information flow (IM1); Lack of clarity on the role, responsibilities and liabilities of a BIM Information Manager (IM2); Ambiguity in sharing information procedures (IM3); Contractual document prevalence (IM4); Undefined roles and responsibilities of contractual parties (LB1); Unclear liability for data amendments and modifications (LB2).
Relational Contracting Elements and the Factors	
Coordination	Clearly defined information sharing procedures (CM4); Well-established procedures for data and information changes (CM6), Practical relational work plan (CR1); Clear working structure (CR2); Clear tasks procedures (CR3); Pre-construction planning structure (CR4); Method statement in coordination with site team (CR5); Quality-enhancement plan (CR6); Early involvement of all parties (CR7); Active participation in discussions (CT1); The requirement for parties to practice role integrity in fulfilling duties (CT2); Joint decision-making (CO1); Joint problem-solving (CO2); Early involvement of top management from various parties (CO3); Clear definition of roles, responsibilities and limitation of power (TC1); Well-defined reporting method (TC3); Joint-declaration statement of achieving mutual objectives (CB1).
Communication	Co-location of different organisations (CM2) Equal access to project information (CM5)
Mutual trust	Incentives and bonuses for achieving agreed goals (WP1); Pain and gain sharing mechanism (WP2); Training for collaboration knowledge and skills (MT1); Risk management workshop (MT2); Early warning systems to allow proactive risk allocation and mitigation (MT3); Contractual solidarity (MT4).

CONCLUSION

This study identified 16 critical BIM contractual risks and 25 Relational Contracting Factors (RCFs) that support the integration of Relational Contracting Elements (RCEs) in BIM-enabled contractual arrangements. From the overall analysis, issues related to information coordination and flow among project stakeholders emerged as the most significant contractual risk, reflecting persistent challenges in managing shared BIM data. In terms of relational solutions, coordination and communication were revealed as the strongest RCE dimensions, while mutual trust, although important, demonstrated lower factor strength and therefore requires deliberate contractual support mechanisms to operationalise effectively. These findings highlight the potential of relational governance to

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reduce adversarial behaviour in BIM projects and improve collaboration. Future research should assess industry acceptance and contractual feasibility of embedding these RCEs into BIM project agreements and test their impact in real project settings.

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