INTERNATIONAL JOURNAL OF INDUSTRIAL MANAGEMENT
ISSN: 2289-9286 E-ISSN: 0127-564X
VOLUME 19, NO. 2, 2025, 92 - 103
DOI: https://doi.org/10.15282/ijim.19.2.2025.11318

RESEARCH ARTICLE

INFLUENCE OF TECHNICAL CHALLENGES ON CONSTRUCTION PROJECT CONTRACTING

Charles Egyabeng Coleman[1,2]*, Erastus Misheng'u Mwanaumo[1], Mundia Muya[1], Rahimi Abdul Rahman[3]

[1]Department of Civil and Environmental Engineering, University of Zambia, Lusaka Zambia
[2]Department of Construction Technology and Management, Cape Coast Technical University, Cape Coast, Ghana
[3]Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Kuantan, Malaysia

ABSTRACT - The construction industry plays a crucial role in economic development by providing essential infrastructure, creating jobs, and supporting other industries. However, this sector faces persistent technical challenges that impede successful project contracting, including issues, such as inadequate supervision, unskilled labour, and outdated equipment. Despite the industry's importance, there is limited research on how these technical challenges impact project contracting, creating a gap in understanding and addressing these issues effectively. This study investigates the influence of technical challenges on project contracting in construction. The data were gathered using a structured survey and Structural Equation Modelling (SEM) was used to analyse the impact of challenges like resource shortages, supply chain issues, and insufficient workforce skills on contracting outcomes. The findings revealed lack of qualified supervision, unskilled labour resulting in poor workmanship, material shortages due to defective supply chains, and ambiguous project specifications as significant challenges that influence projects. The structural equation modelling confirms the reliability of the proposed model, highlighting the interplay between identified technical challenges and their latent constructs. These findings highlight the need to invest in training programs in ensuring that project supervisors and managers possess the necessary qualifications and skills to effectively oversee construction projects. The study concludes by outlining suggestions for further research to deepen the understanding of technical challenges in the delivery of construction contracts and inform evidence-based strategies for industry improvement. This research not only addresses gaps in current literature but also provides practical recommendations for optimising contract deliverables in the construction industry.

ARTICLE HISTORY

Received	:	23-08-2024
Revised	:	30-10-2024
Accepted	:	31-12-2024
Published	:	02-06-2025

KEYWORDS
Project contracting
Contract deliverables
Technical challenges
Project success
SEM

1. INTRODUCTION

Tibaijuka (2013) highlights that the construction industry is vital to economic development, contributing to growth, facilitating infrastructure provision, and shaping the built environment. Despite its pivotal role, the industry faces a range of technical challenges that undermine successful project contracting, such as inadequate supervision, unskilled labour, and limited access to essential resources (Alaloul et al., 2020). These challenges can lead to delays, increased costs, and reduced project quality, thereby impacting stakeholder satisfaction and overall project success (Ullah et al., 2017). Recognising and addressing these challenges is critical for achieving successful project outcomes and enhancing the efficiency of construction operations (Abdullahi & Tembo, 2023). Such challenges not only hinder project progress but also pose serious risks to investors, contractors, project managers, and end users (Eccles & Klimenko, 2019).

Furthermore, these challenges undermine the overall effectiveness and efficiency of the construction process, leading to frustration among stakeholders and harming the industry's reputation (Kahvandi et al., 2019; Famiyeh et al., 2017). While technical challenges are widely recognised as common obstacles in the construction sector, there is a notable lack of detailed research on their specific impact on the successful completion of building contracts. Although various aspects of construction project management and performance have been explored (Ahadzie, 2007; Gyadu-Asiedu, 2009; Demirkesen, & Ozorhon, 2017), there is still a need for a more focused investigation into the mechanisms behind technical challenges and their effects on contract deliverables. This study aims to address such gap by thoroughly examining how technical challenges influence construction project contracts.

This study investigates the influence of technical challenges on construction project contracting. This will be achieved by:

1. Identifying the main technical challenges affecting construction project contracting.
2. Categorising these challenges based on their severity and impact on contract deliverables.
3. Developing a latent model using Structural Equation Modelling (SEM) to analyse and validate the relationships between these challenges, thereby assessing their combined influence on project success.

***CORRESPONDING AUTHOR | C.E Coleman** | ✉ charles.coleman@cctu.edu.gh

The significance of this study lies in its identification and analysis of the core technical challenges impacting construction project contracting. By developing a latent model using Structural Equation Modelling (SEM), the study provides industry stakeholders, such as construction managers, contractors, and policymakers, with insights to prioritise and address key issues like supervision quality, workforce skills, and supply chain reliability. These findings support practical improvements in resource allocation, project supervision, and training programs, thus helping to reduce delays, cost overruns, and quality issues. Additionally, the study contributes to academic research by offering a structured approach for understanding the influence of technical challenges, ultimately guiding future research and policy development aimed at improving construction contract deliverables.

2. LITERATURE REVIEW

The construction industry plays a pivotal role in global economic development; yet, it faces a range of technical challenges that undermine project success. These challenges include resource shortages, insufficient workforce skills, and inadequate supervision, which often result in delays, cost overruns, and compromised quality. Addressing these challenges is crucial for improving contract deliverables and enhancing the industry's overall efficiency (Alaloul et al., 2020; Amoatey & Ameyaw, 2015).

2.1 Technical Challenges in Construction

Research indicates that technical challenges are among the significant barriers to successful project contract delivery. These challenges impact various project aspects, from planning to execution. For example, inadequate supervision and insufficiently trained labour are key factors affecting project quality, leading to rework and increased costs (Hwang, Ngo, & Teo, 2022). Similarly, resource shortages, often caused by ineffective supply chains, delay project timelines and add substantial costs (Smith, Merna, & Jobling, 2014). Each of these challenges requires targeted strategies to mitigate their impact on project contracting (Azis et al., 2012).

The literature highlights the complex nature of technical challenges in construction projects, where factors like labour skills, supervision quality, and resource availability significantly influence contract deliverables. Skilled labour enhances project efficiency, reduces errors, and contributes to overall quality, while unskilled labour can lead to poor craftsmanship and rework (Jiang et al., 2006; Tessema et al., 2022). Inadequate supervision is also shown to be a recurring issue that directly impacts safety, performance, and project timelines (Parson, 2020).

2.2 Project Contracting in Construction

Project contracting is an agreement between parties that defines the responsibilities, deliverables, timelines, and costs associated with a construction project. In simple terms, this contract form is a legally binding agreement that outlines the work that a general contractor will do and the payment that a project owner will make (Malsam, 2024). Project contracting and management is a crucial guarantee for construction projects to be implemented smoothly. Contracting types in construction vary based on project scope, complexity, and risk-sharing preferences. These contracts are critical in the construction management process. Common contracting types include fixed-price contracts, which establish a set price for the project regardless of actual costs. Such contracts are often used in projects with well-defined scopes as they offer certainty in budgeting. However, they are vulnerable to cost overruns and delays if technical challenges arise unexpectedly, placing financial risk on contractors (Kerzner, 2017).

The second contracting type is cost-plus contracts, where contractors are reimbursed for costs incurred plus a predetermined profit margin. It provides flexibility to accommodate unforeseen technical challenges, such as resource shortages or labour issues, but can lead to budget inflation if not carefully managed (Hartman & Snelgrove, 1996). Third is time-and-materials contracts, which are based on the actual time and materials required for the project, making them suitable for projects where the scope may change. However, they can be less predictable in terms of total cost as unanticipated technical challenges may lead to prolonged timelines and higher expenses (Fisk, 2003; Roy, 2016). Finally, design-build contracts combine design and construction services under a single agreement. While this integrated approach can streamline processes and reduce conflicts, it may also complicate the allocation of technical challenges between designers and builders, requiring close collaboration and shared responsibility (Chan, Tam, & Cheung, 2005).

Understanding the dynamics of these contract types is essential for effectively managing the technical challenges that can affect each type differently. For instance, in fixed-price contracts, unanticipated technical issues can lead to significant financial losses for contractors as they bear the burden of costs beyond the set budget (Ibbs et al., 2007). Conversely, cost-plus and time-and-materials contracts offer flexibility to manage technical challenges but may result in higher overall costs if issues are not proactively controlled.

2.2 Impact of Technical Challenges on Project Contracting

The effects of technical challenges on project contracting are well-documented. Issues like unskilled labour, inadequate supervision, and outdated equipment have been reported to disrupt project schedules, increase costs, and reduce quality, thus impacting the project's overall success and the probability of contract cancellation (Kaming, Maryani, & Boenardi, 2018; Coleman et al., 2023). Studies have shown that when technical issues are not addressed early, they can escalate into more significant problems that compromise project objectives (Grant et al., 2012; Riegel, 2023). In the context of project contracting, technical challenges often necessitate contract adjustments, leading to increased administrative overhead and potential disputes among stakeholders. Effective project contracting, therefore, requires robust planning, skilled labour management, and efficient resource allocation to mitigate the adverse effects of these challenges (Carvalho et al., 2022). The current literature underscores the importance of proactive strategies, such as workforce training, technological upgrades, and transparent communication, to address technical challenges and enhance project success rates (Gyadu-Asiedu, 2009; Smith et al., 2007).

3. DATA AND METHODOLOGY

3.1 Research Design

This study was designed to thoroughly explore the impact of technical challenges on project contracting within the construction industry. A quantitative research design was employed to systematically assess the frequency, severity, and impact of technical challenges on project contracting. Primary data were obtained from a diverse group of construction industry professionals to facilitate statistical analysis and the development of a robust conceptual model (Bloomfield & Fisher, 2019). For this purpose, a structured questionnaire was developed to gather information on various technical challenges affecting project success. A pilot study was done to ensure the reliability, relevance, and clarity of all items, followed by a full-scale data collection. Finally, Structural Equation Modelling (SEM) was used to analyse the data.

3.2 Survey Development and Item Clarification

The questionnaire survey used in this study was developed following an extensive review of past literature. It consisted of 9 items covering various dimensions of technical challenges, including supervision, labour skills, resource shortages, and equipment adequacy. Each item was designed to capture specific aspects of the challenges, thus enabling comprehensive analysis of their impact on project contracting. Respondents were asked to indicate their level of agreement to each item using a five-point Likert scale ranging from 1 (Not at All) to 5 (Very High Extent). Several closed-ended questions were also included to support the quantitative analysis. Finally, a pilot study was conducted involving ten experts with extensive experience in construction project management to refine the survey instrument and ensure the clarity, relevance, and reliability of the items before full-scale data collection.

3.3 Sample and Sampling Method

The sample of this study encompassed senior contract managers, experienced quantity surveyors, and other high-level professionals whose perspectives were crucial for understanding the full scope of the challenges faced in construction project contracting. Purposive sampling was employed to select these individuals with specialised knowledge and extensive experience in construction project management. This approach ensures the inclusion of key informants who can provide deep insights into the topic under investigation, which contributes to the depth and breadth of the data and ultimately improves the generalisability and reliability of the findings (Rai & Thapa, 2015).

3.4 Data Collection and Analysis

Before the study commenced; a consent form was provided to all respondents through their respective heads of divisions. It outlined essential details about the research, including the title, objectives, goals, and scope. Next, a copy of the questionnaire was distributed to the respondents to collect primary data regarding the challenges faced in construction project contracting. Additionally, secondary data were gathered from existing literature, such as journal articles, books, and reports, to supplement the quantitative findings. All quantitative data underwent an initial screening to address any missing values or outliers, a normality test using skewness and kurtosis to ensure data suitability, reliability and validity checks using Cronbach's alpha, and assessments of convergent and discriminant validity.

The quantitative data was analysed using Structural Equation Modelling (SEM) via the AMOS software. Specifically, Covariance-Based SEM (CB-SEM) was done rather than Partial Least Squares SEM (PLS-SEM), following its effectiveness in testing theoretical frameworks and modelling latent constructs. This approach enabled a comprehensive analysis of relationships among various technical challenges in construction project contracting (e.g., supervision quality, workforce skills, and supply chain reliability) to better understand their combined impact on contract deliverables. Furthermore, the sample size of more than 200 respondents not only met the recommended threshold for CB-SEM but also enabled a comprehensive analysis of potential issues related to construction project contracting (Krejcie & Morgan, 1970).

The data analysis process encompassed two key steps: measurement model testing and structural model testing. A Confirmatory Factor Analysis (CFA) validated the measurement model by assessing goodness-of-fit indices, such as the Comparative Fit Index (CFI), Normed Fit Index (NFI), and Root Mean Square Error of Approximation (RMSEA). Subsequently, the structural model was tested to examine the hypothesised relationships between latent variables using path coefficients, standard errors, and significance levels, aiming to evaluate the direct and indirect effects of each technical challenge on contract deliverables.

3.5 Methodology Flowchart

The flowchart in Figure 1 illustrates the steps and processes involved over the course of this study.

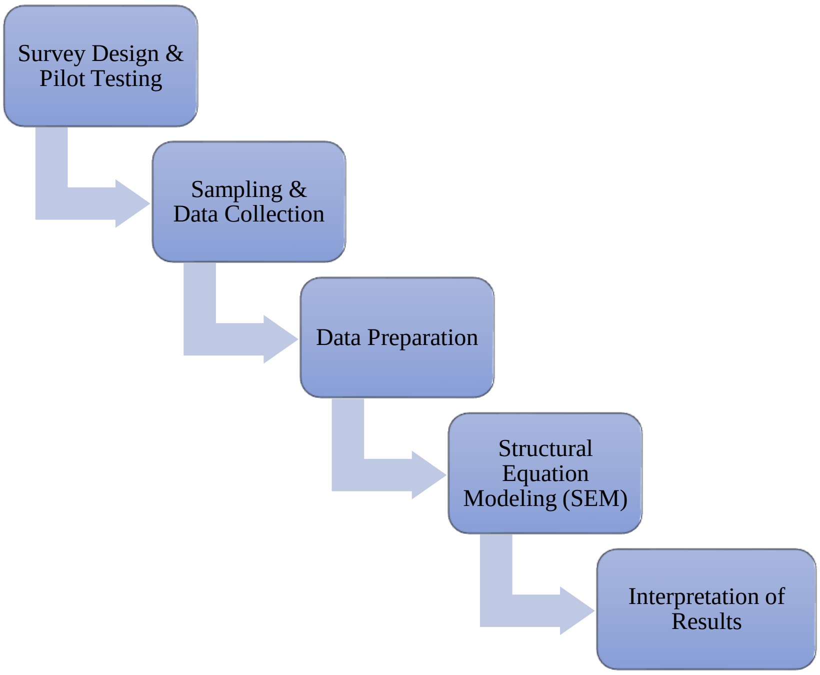

Figure 1. Flowchart of research methodology

4. RESULTS AND DISCUSSION

4.1 Respondents' Profiles

This section presents the percentage distribution of the respondents based on their background characteristics, including education, occupation, employment history, organisation, and specialisation within the construction industry. The respondents' profiles were assessed to ensure they were appropriate for the research group and to enhance the reliability of their responses. Clearly stating the reliability and validity of the research methods is crucial for maintaining transparency and minimising researcher bias (Mohajan, 2017; Singh et al., 2021).

Table 1 provides a summary of the respondents' background characteristics. From the 315 total responses collected during the survey, 26.7% were procurement officers, 33% were quantity surveyors, 23.2% were engineers, 7.9% were contract managers, 3.8% were architects, 3.8% were project managers, and 1.6% were lecturers. The results revealed that quantity surveyors and procurement officers comprised the largest segments of professionals in the sample. In terms of professional background, 26.7% were procurement officers, 33% had expertise in quantity surveying, 23.2% were engineers, 7.9% were contract managers, 3.8% were architects, 3.8% were project managers, and 1.6% were lecturers. Regarding industry experience, 37.1% of respondents had 6-10 years of experience, 28.3% had 11-15 years, 21.9% had 16-20 years, and 12.7% had over 21 years.

Table 1. Respondents' profiles

Characteristics	N	Percentage	Characteristics	N	Percentage
Profession			Years Practiced		
Contract manager	25	7.9	6-10 years	117	37.1
Procurement officer	84	26.7	11-15 years	89	28.3
Quantity surveyor	104	33	16-20 years	69	21.9
Engineer	73	23.2	21 years and above	40	12.7
Architect	12	3.8	Current specialisation		
Project manager	12	3.8	Building works only	121	38.4
Lecturer	5	1.6	Civil works only	69	21.9
Qualification			Building and civil works	125	39.7
Higher National Diploma (HND)	8	2.5	Total	315	100
BSc/BTech	165	52.4	Employer		
Masters	138	43.8	Public sector	248	78.7
PhD/DPhil/DTech	4	1.3	Private sector	67	21.3
			Total	315	100.0

Concerning their current specialisation, 39.7% were engaged in both building and civil works, 38.4% specialised exclusively in building works, and 21.9% focused solely on civil works. Finally, the professional qualifications data indicated that 78.7% of respondents were employed in the public sector, while 21.3% worked in the private sector.

Descriptive analysis was performed to summarise the data and identify patterns and relationships within the dataset. Factor Analysis (FA) was applied to achieve the research objectives. Exploratory Factor Analysis (EFA) was conducted using multivariate correlation coefficient analysis via SPSS version 26, followed by Confirmatory Factor Analysis (CFA). Meanwhile, Structural Equation Modelling (SEM) was done via AMOS version 22. Such method was selected for its ability to model latent variables, address measurement errors, and define the covariance structure (Henseler, 2021). The SEM analysis indicated that all the variables examined were significant. The SEM procedures included evaluating the measurement model through CFA and assessing the structural model using goodness of fit indices. This method allowed for hypothesis testing of the relationships between observed variables and their underlying latent constructs. By employing SEM, the researcher was able to analyse both the direct and indirect effects of various factors on construction contract cancellation, offering insights into the mechanisms driving these relationships (Li et al., 1998).

4.2 Descriptive Statistics

Descriptive statistics, such as means, standard deviations, and percentages, were used to summarise the data for analysis. The researchers aimed to evaluate the effect of technical challenges on construction project contracting through nine measurement indicators. The respondents' level of agreement or disagreement with these indicators was determined using the scale developed by Koomson (2017) and Gwet (2014). According to this scale, a mean score of 2.9 or below indicates disagreement, whereas 3.0 or above indicates agreement. Technical challenges related to contract delivery are detailed in Table 2. Table 2 outlines the specific causes of construction contract cancellations in Ghana. Technical challenges were identified as a major factor, which was detailed through nine distinct items. The most significant cause was inadequate supervision, which was rated highest with a mean score of 4.1 (SD = 0.958). The second major factor was unskilled labour resulting in poor workmanship (M = 3.88, SD = 1.027), followed by poor machinery and outdated equipment (M = 3.78, SD = 1.047), and material shortages due to defects in the supply chain (M = 3.62, SD = 0.972). The following sections will further examine the impact of these technical challenges on construction contract cancellation.

The results in Table 2 also indicate that all variables used in the study are approximately normally distributed. Each variable's skewness and kurtosis values fall within the acceptable range of -1 to +1, which suggests no extreme deviations from normality. This normal distribution of data across variables confirms that they meet the assumptions required for conducting Structural Equation Modelling (SEM). Consequently, the data's normality supports the validity and reliability of the SEM analysis in assessing the relationships among the technical challenges in construction project contracting.

Table 2. Results for technical challenges of project contracting and normality tests (Skewness and Kurtosis)

Variable	Mean	Std. Dev.	Skewness	Kurtosis
Lack of qualified supervision	4.01	0.958	-0.15	0.40
Unskilled labour resulting in poor workmanship	3.88	1.027	0.05	-0.12
Poor machines and obsolete equipment	3.78	1.047	0.12	-0.09
Material shortage due to defective supply chain	3.62	0.972	-0.23	-0.05
Poor management of construction personnel	3.50	0.918	0.10	-0.08
Incompetent designers in design team	3.43	0.909	-0.18	-0.14
Technological problems and unsuitable tools	3.43	0.943	0.04	0.13
Ambiguous project specifications	3.29	0.953	0.08	-0.07
Technical challenges remain difficult	3.06	1.019	-0.11	0.15

Table 3. Results of non-response bias tests (comparison of early and late respondents)

Variables	Early Respondents (Mean)	Late Respondents (Mean)	t-Statistic	p-value
Lack of qualified supervision	4.03	3.98	0.43	0.67
Unskilled labour resulting in poor workmanship	3.87	3.89	-0.18	0.85
Poor machines and obsolete equipment	3.76	3.80	-0.25	0.80
Material shortage due to defective supply chain	3.61	3.63	-0.25	0.80
Poor management of construction personnel	3.48	3.53	-0.40	0.69
Incompetent designers in design team	3.45	3.41	0.31	0.75
Technological problems and unsuitable tools	3.44	3.42	0.15	0.88
Ambiguous project specifications	3.27	3.31	-0.31	0.75
Technical challenges remain difficult	3.04	3.08	-0.20	0.84

Table 3 shows a comparison between the mean responses of early and late respondents on key variables to assess potential non-response bias. The p-values for all variables are above 0.05, indicating no statistically significant differences between early and late responses. This suggests minimal risk of non-response bias in the data, denoting those responses are consistent regardless of when respondents completed the survey. As a result, the data can be considered representative of the target population, thus enhancing the credibility of the findings.

4.3 Exploratory Factor Analysis

Exploratory factor analysis (EFA) is a statistical technique designed to uncover the underlying structure of a set of observed variables and identify the relationships between them (Fabrigar, 2012). It simplifies data complexity by grouping variables into factors based on their correlations, which represent latent constructs.

Table 4. Results for exploratory factor analysis

Challenge	Components		Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
	CTC	TC			
Poor machines and obsolete equipment	0.832		0.619	0.826	0.849
Material shortage due to defective supply chain	0.769		0.613	0.827	
Unskilled labour resulting in poor workmanship	0.700		0.648	0.821	
Lack of qualified supervision	0.686		0.727	0.804	
Technical problems and unsuitable tools	0.666		0.593	0.831	
Incompetent designers in design team	0.636		0.591	0.831	
Technical challenges remain extremely difficult and unresolvable		0.809	0.416	0.538	0.818
Ambiguous project specifications		0.749	0.454	0.481	
Poor management of construction personnel		0.543	0.414	0.538	

The one-dimensionality and reliability of the Technical Challenges (TC) construct were evaluated through EFA while Principal Component Analysis (PCA) with Varimax rotation was employed as the extraction and rotation method. The construct was measured using nine specific parameters. The findings confirmed that factor analysis was applicable to the data, with each of the nine parameters (TC1 - TC9) loading onto two distinct components.

In this study, a factor loading threshold of 0.5 was applied in line with the guidelines of Costello (2019) and Black, Babin, and Anderson (2010). In the first component, six items measuring Critical Technical Challenges (CTC) surpassed the threshold, namely poor machines and obsolete equipment, material shortage due to defective supply chain, unskilled labour resulting in poor workmanship, lack of qualified supervision, technical problems and unsuitable tools, and incompetent designers in design team. In the second component, three items measuring Technical Challenges (TC) exceeded the threshold, namely technical challenges remain extremely difficult and unresolvable, ambiguous project specifications, and poor management of construction personnel. As shown in Table 3, the item-total correlation adjusted for items within the component was extracted using a proposed cut-off value of 0.30 after EFA. The items were considered reliable measures of the components as indicated by Cronbach's alpha coefficients of 0.849 for the CTC component and 0.818 for the TC component, demonstrating very good internal reliability (Kline, 2023).

4.4 Structural Equation Model

Both PCA and EFA were employed before the confirmatory analysis to verify the one-dimensionality and reliability of the construct. According to Marsh (2005) and Byrne (2016), standard goodness-of-fit indices should be used to evaluate measurement models for the Technical Challenges Factors (TCF) construct. The confirmatory analysis yielded an S-Bχ2 value of 3.872 with 26 degrees of freedom and a p-value of 0.0000, indicating a good fit for the model. The path coefficients were significant and positive at $p < 0.05$, demonstrating strong alignment. Although chi-square is sensitive to sample size and is not recommended for samples smaller than 50, Byrne (2016) suggests it is sometimes used descriptively. As shown in Table 4, the Comparative Fit Index (CFI) was 0.922 while the Normed Fit Index (NFI) was 0.998, both surpassing the 0.90 threshold. Therefore, the model is considered appropriate. However, the Parsimonious Normed Fit Index (PNFI) was 0.649, which fell short of the 0.80 threshold. The Root Mean Square Residual (RMR) was 0.034, below 0.05, and the Goodness of Fit Index (GFI) was 0.929, exceeding 0.90. These indices indicate that the TCF model provides a satisfactory explanation of the data.

A unidimensional model containing the properties of TCF is shown in Figure 2 and Table 6. All nine indicator variables were gathered for the final CFA (Byrne, 2016; Bonifay et al., 2015). From the 315 instances examined for this construct, only 12 indicator variables were found, consisting of two components realised as CTC (CTC1, CTC2, CTC3, CTC4, CTC5, and CTC6) and TC (TC1, TC2, and TC3).

Table 5. Results for robust fit index for technical challenges factor

Fit Index	Cut-Off Value	Estimate	Comment
S – Bχ^2		3.872	
Df	0≥	26	Acceptable
CFI	0.90≥ acceptable 0.95≥ good fit	0.922	Good fit
PCFI	Less than 0.80	0.666	Good fit
RMSEA	Less than 0.08	0.068	Acceptable
RMSEA 95% CI	0.00-0.08 "good fit"	0.013-0.076	Acceptable
NFI	Greater than 0.90 "good fit"	0.998	Good fit
IFI	Greater than 0.90 "good fit"	0.923	Good fit
PNFI	Less than 0.80	0.649	Good fit
RMR	Less than 0.05 "good fit"	0.034	Good fit
GFI	Greater than 0.90 "good fit"	0.929	Good fit

Note: *S-Bx^2 = Chi-Square, DF = Degree of Freedom, CFI = Comparative Fit Index, PCFI =Parsimony Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, RMSEA 95% CI = Root Mean Square Error of Approximation 95% Confidence Interval, NFI = Normed Fit Index, IFI = Incremental Fit Index, PNFI = Parsimony Normed Fit Index, RMR = Root Mean Residual and GFI = Goodness of Fit Index.*

Table 6. Final conceptual model indicator variables for technical challenges factor

Latent Component	Indicator Variable	Measurement Variable	Label
Critical Technical Challenges (CTC)		Poor machines and obsolete equipment	CTC1
		Material shortage due to defective supply chain	CTC2
		Unskilled labour resulting poor workmanship	CTC3
		Lack of qualified supervision	CTC4
		Technical problems and unsuitable tools	CTC5
		Incompetent designers in design team	CTC6
Technical Challenges (TC)		Technical challenges remain extremely difficult & unresolvable	TC1
		Ambiguous project specifications	TC2
		Poor management of construction personnel	TC3

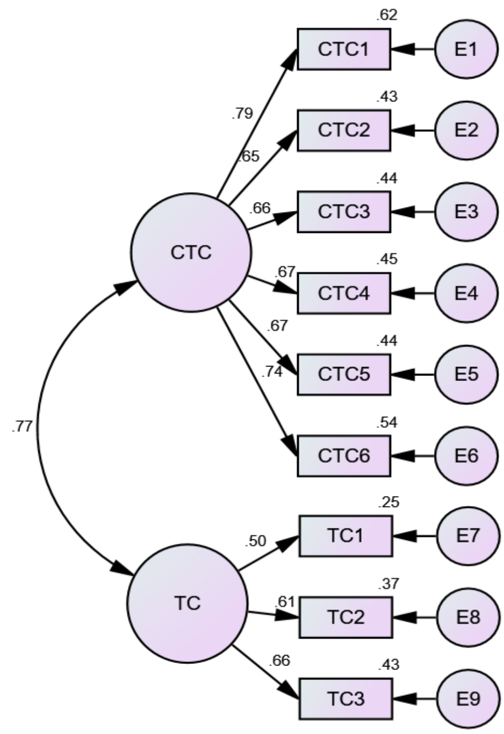

Figure 2. CFA model for technical challenges factor (TC)

Table 7 displays the correlation coefficients, standard errors, and statistical test results for the final model with nine indicators. All correlation values were below 1.00 and each p-value was below the significance level of 0.05, indicating that the estimates were deemed acceptable and statistically significant. The indicator with the highest standardised coefficient was CTC1, which had a parameter coefficient of 0.787.

Table 7. Factor loading and p-value of technical challenges factor

Hypothesised Relationships (Path)	Unstandardised Coefficient (λ)	Standardised Coefficient (λ)	P-Value	R- Square	Sig. at 5% Level
CTC1 ← CTC	1.000	0.787	0.00	0.619	Yes
CTC2 ← CTC	0.770	0.652	0.00	0.425	Yes
CTC3 ← CTC	0.830	0.665	0.00	0.442	Yes
CTC4 ← CTC	0.777	0.668	0.00	0.446	Yes
CTC5 ← CTC	0.763	0.666	0.00	0.444	Yes
CTC6 ← CTC	0.815	0.738	0.00	0.544	Yes
TC1 ← TC	1.000	0.500	0.00	0.250	Yes
TC2 ← TC	1.139	0.609	0.00	0.370	Yes
TC3 ← TC	1.183	0.656	0.00	0.430	Yes
CTC ⇔ TC			0.00	0.766	Yes

Most parameter estimates exhibited high correlations nearing 1.00, which indicates a strong linear connection between the indicator variables (CTC) and the latent variables (TC). The R^2 values were close to the ideal value of 1.00, implying that the factors explained a significant portion of the variance in the indicator variables. This suggests that the indicator variables are robust predictors of the latent constructs. The significant correlations between the components (CTC and TC) and all measured variables further validate this finding in the context of technical issues.

5. CONCLUSIONS

5.1 Summary of Findings and Conclusion

The results of this study are aligned with existing literature and shed light on the intricate connection between technical challenges and the successful completion of construction project contracts. A major concern reported by the respondents was the lack of competent supervision, which echoes previous research highlighting the crucial role of effective project management in mitigating construction risks (Dissanayaka & Kumaraswamy, 1998). This underscores the necessity for contract managers and quantity surveyors to possess the expertise and skills required to effectively manage complex construction scenarios. Moreover, the construction industry continues to face the ongoing issue of untrained workers, resulting in poor craftsmanship, inadequate machinery, and outdated equipment (Ayinkamiye, 2019). These findings are consistent with previous studies that underscored the detrimental effects of insufficient labour skills and obsolete equipment on project outcomes, such as delays and cost overruns (Kaming et al., 2018). The heightened awareness of supply chain weaknesses in the construction industry aligns with the recognition of material shortages as a significant issue caused by flawed supply networks (Carvalho et al., 2022). Effective supply chain management practices are essential to enhance material availability, streamline project processes, minimise disruptions, and optimise overall project performance.

This research underscores the importance of addressing technical challenges and vague project specifications as these factors can hinder project progress and compromise deliverables (Smith et al., 2007). By clarifying these challenges, this study enhances the current understanding of the intricate connection between technical problems and project completion. Additionally, the SEM analysis elucidates the relationships between the identified technical challenges and their core concepts. The strong fit indices reaffirm the model's effectiveness in capturing the underlying dynamics of technical challenges in construction projects (Hair, 2017). In conclusion, addressing technical challenges in construction contracting requires targeted approaches to improve resource management, workforce training, and project supervision. These findings provide valuable insights for industry practitioners and contribute to the field of construction management by offering practical recommendations to enhance contract deliverables.

5.2 Research Implications

This study provides valuable insights into the technical challenges of fulfilling construction project contracting through quantitative analysis and Structural Equation Model (SEM). A key finding is the lack of qualified supervision, thus highlighting the critical role of effective project monitoring in successful project implementation. This underscores the necessity for skilled project managers with the expertise to navigate the complexities associated with construction projects. The findings also revealed that unskilled workers, poor-quality construction projects, and outdated machinery and equipment are prevalent issues. It emphasises the importance of investing in staff training programs and updating equipment to enhance project quality and efficiency.

Another significant issue is the shortage of materials caused by broken supply chains, which highlights the vulnerability of construction projects to delays in procurement. Addressing these supply chain inefficiencies and establishing robust procurement practices is crucial for ensuring a steady supply of materials throughout the project timeline. Additionally, this study clarifies how unclear project specifications and technological issues impact the execution of construction contracts. It underscores the importance of leveraging technology and maintaining clear communication to optimise project operations and minimise miscommunication. The Structural Equation Model (SEM) further validated the relationships between the identified technological issues and their underlying components. The strong fit indices confirmed that the proposed model effectively captured the core dynamics of technical challenges in construction project contracting.

This study provides practical recommendations to improve project contract deliverables by addressing technical challenges. Industry stakeholders, including contractors, project managers, and policymakers, can use these insights to enhance project planning, resource allocation, and workforce development strategies. Investing in skill-building initiatives and modernising equipment can mitigate the adverse effects of technical challenges, leading to better project quality and efficiency.

5.3 Recommendations and Future Research Recommendations

Based on the research findings and conclusions, several key recommendations can be made:

i) Invest in training programs to ensure that project supervisors and managers possess the necessary qualifications and skills to effectively oversee construction projects. Implement robust monitoring mechanisms to ensure compliance with project requirements and quality standards throughout the construction process.

ii) Develop initiatives aimed at improving the skills and competencies of construction workers. Provide training programs focused on enhancing technical expertise, safety practices, and productivity to mitigate the impact of unskilled labour on contract deliverables.

iii) Allocate resources to upgrade and modernise construction equipment and machinery. Invest in state-of-the-art technology to improve efficiency, productivity, and safety on construction sites. Regular maintenance and replacement of obsolete equipment should be prioritised to minimise disruptions and delays.

iv) Enhance the clarity and specificity of project specifications to reduce ambiguity and misunderstandings. Foster open communication channels between stakeholders to ensure that project requirements are clearly defined and understood from the outset. Consider employing digital tools and platforms to streamline the exchange of project information and documentation.

v) Embrace innovative technologies, such as Building Information Modelling (BIM), construction management software, and drones to optimise project planning, coordination, and execution. Implement digital solutions for project monitoring, progress tracking, and quality control to enhance transparency and accountability.

While this study has shed light on the technical challenges faced by construction projects, several research directions may improve the current understanding of this intricate field. Future research can investigate the geographical disparities in technical challenges encountered by the construction industry. Examining how geographical location, legal frameworks, and cultural distinctions influence the frequency and intensity of technical challenges might yield insightful information for stakeholders functioning in various environments.

ACKNOWLEDGEMENTS

All authors acknowledge the support from Mr. Eric Alaah Atindoo and Mr. Isaac Agyei-Mensah during data collection. We also thank Mr. Patrick D. Saami and Mr. Abdul-Rahman Nasiru for their technical and administrative supports. We acknowledge the special contribution from RUFORUM, Cape Coast Technical University, and University of Zambia in the form of financial support.

FUNDING STATEMENT

The authors did not receive financial support for this work.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analysed in this study are provided in full within the published article.

AUTHORS CONTRIBUTION

C. E. Coleman (Conceptualisation; Design; Methodology; Data collection; Data analysis; Writing – original)

E. M. Mwanaumo (Supervision; Manuscript review)

M. Muya (Supervision; Manuscript review)

R. A. Rahman (Supervision; Manuscript review)

CONFLICT OF INTEREST

All authors declare that there is no conflict of interest in the work presented in this manuscript.

ETHICS STATEMENT

The study was conducted in accordance with the Declaration of the University of Zambia and the protocol was approved by the Ethics Committee of Directorate of Research of Graduate Studies (DRGS approval no. NASREC: 2022-JUL-003). An informed consent was obtained from all individual respondents who participated in the study.

REFERENCES

Alaloul, W. S., Liew, M. S., Zawawi, N. A. W. A., & Kennedy, I. B. (2020). Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders. Ain Shams Engineering Journal, 11(1), 225-230.

Azis, A. A. A., Memon, A. H., Rahman, I. A., Nagapan, S., & Latif, Q. B. A. I. (2012, September). Challenges faced by construction industry in accomplishing sustainability goals. In 2012 IEEE Symposium on Business, Engineering and Industrial Applications (pp. 630-634). IEEE.

Abdullahi, C. M., & Tembo, M. (2023). Improving the efficiency and effectiveness of construction project planning and scheduling using lean principle. International Journal of Construction Engineering and Management, 12, 75-80.

Ahadzie, D. K. (2007). A model for predicting the performance of project managers in mass house building projects in Ghana. University of Wolverhampton, PhD Thesis Online.

Ayinkamiye, A. (2019) The role of project planning on the performance of government project in Rwanda, University of Rwanda. PhD Thesis Online.

Amoatey, C. T., Ameyaw, Y. A., Adaku, E., & Famiyeh, S. (2015). Analysing delay causes and effects in Ghanaian state housing construction projects. International Journal of Managing Projects in Business, 8(1), 198-214.

Bloomfield, J., Fisher, M. J. (2019) Quantitative research design. Journal of the Australasian Rehabilitation Nurses Association. 22(2), 27-30.

Black, W. C., Babin, B. J., & Anderson, R. E. (2010). Multivariate data analysis: A global perspective. Pearson.

Byrne, B. M. (2013). Structural equation modeling with Mplus: Basic concepts, applications, and programming. Routledge.

Bonifay, W. E., Reise, S. P., Scheines, R., & Meijer, R. R. (2015). When are multidimensional data unidimensional enough for structural equation modeling? An evaluation of the DETECT multidimensionality index. Structural Equation Modeling: A Multidisciplinary Journal, 22(4), 504-516.

Costello, A. B., & Osborne, J. (2019). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. Practical Assessment, Research, and Evaluation, 10(1), 7-15.

Chan, E. H., Tam, C. M., & Cheung, R. K. (2005). Interorganizational trust and cooperation in construction: A transaction cost economics approach. Building and Environment, 40(5), 621-632.

Carvalho, H., Naghshineh, B., Govindan, K., & Cruz-Machado, V. (2022). The resilience of on-time delivery to capacity and material shortages: An empirical investigation in the automotive supply chain. Computers & Industrial Engineering, 171, 108375.

Coleman, C. E., Mwanaumo, E. M., & Rahman, R. A. (2023). Indicators of failing projects: The case of public construction. In AIP Conference Proceedings (Vol. 2688, No. 1). AIP Publishing.

Dissanayaka, S. M., & Kumaraswamy, M. M. (1998). Comparing contributors to time and cost performance in building projects. Building and Environment, 34(1), 31-42.

Demirkesen, S., & Ozorhon, B. (2017). Impact of integration management on construction project management performance. International Journal of Project Management, 35(8), 1639-1654.

Eccles, R. G. Klimenko, S. (2019). Shareholders are getting serious about sustainability. The Investor Revolution. Harvard Business Review.

Fabrigar, L. R., & Wegener, D. T. (2012). Exploratory factor analysis. Oxford University Press.

Famiyeh, S., Amoatey, C. T., Adaku, E., & Agbenohevi, C. S. (2017). Major causes of construction time and cost overruns: A case of selected educational sector projects in Ghana. Journal of Engineering, Design and Technology, 15(2), 181-198.

Fisk, E. R. (2003). Construction project administration (6th edn.). Prentice Hall.

Gwet, K. L. (2014). Handbook of inter-rater reliability: The definitive guide to measuring the extent of agreement among raters. Advanced Analytics, LLC.

Grant, J., Schofield, M. J., & Crawford, S. (2012). Managing difficulties in supervision: Supervisors' perspectives. Journal of Counseling Psychology, 59(4), 528-536.

Gyadu-Asiedu, W. (2009). Assessing construction project performance in Ghana: modelling practitioners' and client’s perspectives. Technical University of Eindhoven, PhD Thesis Online.

Hartman, F. T., & Snelgrove, P. (1996). Risk management as a key to cost performance. International Journal of Project Management, 14(4), 219-224.

Hair Jr, J. F., Matthews, L. M., Matthews, R. L., & Sarstedt, M. (2017). PLS-SEM or CB-SEM: updated guidelines on which method to use. International Journal of Multivariate Data Analysis, 1(2), 107-123.

Henseler J. Why generalized structured component analysis is not universally preferable to structural equation modeling. Journal of the Academy of Marketing Science. 2012 May; 40:402-13.

Hwang, B. G., Ngo, J., & Teo, J. Z. K. (2022). Challenges and strategies for the adoption of smart technologies in the construction industry: The case of Singapore. Journal of Management in Engineering, 38(1), 05021014.

Jiang, J. J., Klein, G., & Chen, H. G. (2006). The effects of user partnering and user non-support on project performance. Journal of the Association for Information Systems, 7(1), 6-16.

Kahvandi, Z., Saghatforoush, E., ZareRavasan, A., & Preece, C. (2019). Integrated project delivery implementation challenges in the construction industry. Civil Engineering Journal, 5(8), 1672-1683.

Kerzner, H. (2017). Project management: A systems approach to planning, scheduling, and controlling. John Wiley & Sons.

Kaming, P. F., Maryani, D., & Boenardi, M. (2018). Service life planning for electronics, mechanical and electrical components of a hotel building. In MATEC Web of Conferences (Vol. 195, p. 06010). EDP Sciences.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607-610.

Kline, R. B. (2023). Principles and practice of structural equation modeling. Guilford Publications.

Koomson S. (2017) Assessing organizational performance in Ghanaian public sector: The case of information services department in Cape Coast (Doctoral dissertation, University of Cape Coast).

Ibbs, C. W., Kwak, Y. H., Ng, T., & Odabasi, A. M. (2003). Project delivery systems and project change: Quantitative analysis. Journal of Construction Engineering and Management, 129(4), 382-387.

Li, F., Harmer, P., Duncan, T. E., Duncan, S. C., Acock, A., & Boles, S. (1998). Approaches to testing interaction effects using structural equation modeling methodology. Multivariate Behavioral Research, 33(1), 1-39.

Mohajan, H. K. (2017). Two criteria for good measurements in research: Validity and reliability. Annals of Spiru Haret University. Economic Series, 17(4), 59-82.

Malsam, W. (2024) 14 Types of Construction Contracts: Pros, Cons & Best Practices. Construction Project Documents. https://www. projectmanager.com/blog/construction-contracts-best-practices [Accessed on 14/11/24]

Marsh, H. W., Hau, K. T., & Grayson, D. (2005). Goodness of Fit in Structural Equation. Contemporary psychometrics.

Parson, S. J. (2020). Relationship between US construction project managers’ leadership styles and construction project success. Capella University.

Riegel, M. (2023) Encourage Your Team to Escalate Issues on Technical Projects. Harvard Business Review.

Rai, N., & Thapa, B. (2015). A study on purposive sampling method in research. Kathmandu: Kathmandu School of Law, 5(1), 8-15.

Roy, R., Stark, R., Tracht, K., Takata, S., & Mori, M. (2016). Continuous maintenance and the future-foundations and technological challenges. Cirp Annals, 65(2), 667-688.

Smith, N. J., Merna, T., & Jobling, P. (2014). Managing risk in construction projects. John Wiley & Sons.

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., ... & Towprayoon, S. (2007). Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems & Environment, 118(1-4), 6-28.

Singh, N., Benmamoun, M., Meyr, E., & Arikan, R. H. (2021). Verifying rigor: Analyzing qualitative research in international marketing. International Marketing Review, 38(6), 1289-1307.

Tibaijuka, A. (2013). Building prosperity: Housing and Economic Development. Routledge.

Tessema, A. T., Alene, G. A., & Wolelaw, N. M. (2022). Assessment of risk factors on construction projects in Gondar city, Ethiopia. Heliyon, 8(11), 16-23.

Ullah, F., Thaheem, M. J., Siddiqui, S. Q., & Khurshid, M. B. (2017). Influence of Six Sigma on project success in construction industry of Pakistan. The TQM Journal, 29(2), 276-309.