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Assessing Interrelationships Among Causes of Rework in Construction Projects in Nigeria

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Abstract

The cause of rework in construction projects has been linked to latent conditions within the organizational and project systems. This study seeks to evaluate the connections between these latent conditions and their impact on rework in construction projects in Nigeria. Previous literature has not thoroughly explored the interrelationships between the latent conditions influencing rework. To address this gap, a comprehensive literature review was conducted to compile a list of latent conditions that affect rework in construction projects. Subsequently, a survey questionnaire was employed to gather insights from construction firms regarding the extent to which these identified latent conditions impact rework in building construction projects. Through factor analysis, six constructs were identified. A structural equation model (SEM) was then utilized to assess these constructs and explore their interactions using observable variables. The final SEM confirmed seven relationships while rejecting six relationships proposed in the hypothetical model. This study contributes to a deeper understanding of the connections between constructs influencing rework and the degrees of their associations. It offers valuable insights for construction firms to comprehend the emergence and interactions of these relationships, ultimately aiding in error prevention and rework reduction.

Keywords: construction industry, interrelationship, projects performance, rework

1. Introduction

The construction industry in various nations, including Nigeria, faces persistent challenges such as cost and schedule overruns, quality deviations, and customer dissatisfaction (Enshassi et al., 2017). Rework is identified as a significant contributor to these issues, leading to increased project costs and time overruns (Aibiun and Jagboro, 2002).

Rework's detrimental impact on building and engineering projects is substantial, with rework costs ranging from 5 to 20% of the contract value in construction and engineering projects, and 50% of rework attributed to design scope changes (Barber et al., 2000). In Nigeria, rework significantly affects the industry's performance (Kaming et al., 1997). Different definitions and quantification methods further complicate the understanding of rework and its causal nature (Smith,2015). Despite its widespread occurrence and adverse effects on project success, the reasons for rework remain largely unknown, hampering effective management of the issue (Ye et al., 2014).

Identifying the root causes of rework and managing them to minimize their impact on construction projects is crucial. Various studies, both in Australia and Nigeria, have highlighted causes such as design errors, construction changes, and poor detailing and workmanship (Ajayi et al., 2015). In Nigeria, causes of rework include changes, defects, poor communication, sub-standard services, and a lack of commitment to quality (Ogunsemi, 2010). Organizational and managerial decisions are identified as underlying conditions for errors to manifest (Barber et al., 2000). Latent conditions, such as failure to undertake design reviews and limited resources for supervision, contribute to the occurrence of rework (Love et al., 2016).

Despite numerous research efforts to combat rework, projects continue to experience cost and schedule overruns due to errors (Williams et al., 1995). The complexity and interdependency of factors contributing to rework have often been overlooked, hindering progress in developing effective strategies for reducing and containing rework.The complex relationships and interactions among factors contributing to rework is essential for pursuing error and rework reduction (Love et al., 2011).

In Nigeria, efforts have been made to address the issue of rework by identifying its primary causes (Ayetan, 2013). Studies have recognized that rework can be a result of latent conditions within organizational, individual, and project systems (Love et al., 2011). These latent conditions may include factors such as insufficient training, resourcing levels, lack of quality management focus, and errors resulting from lack of supervision and competitive tendering (Love et al., 2011).

Previous research has categorized rework causes and reported their relative importance, but there is a need for a more quantitative understanding of their impact (Misra, 2021). Moreover, understanding the interrelationship between causes influencing rework is crucial for developing effective strategies to reduce and contain rework in construction projects (Love et al., 2019). It is evident that addressing the issue of rework will be more effective when the interrelationships among these conditions are known. Since there is a lack of research in the literature uncovering these interrelationships in the Nigerian construction industry, there is a need to fill this gap to enhance understanding, reduce rework, and improve project performance.

Nigerian Construction Industry

In the 2000s, Nigeria saw an increased demand for better service from the construction industry due to improvements in the procurement system, resulting in significant pressure on contractors to enhance construction productivity and meet sophisticated client requirements. As a result, projects grew in size, design, complexity, and construction difficulty, while the development cycle was shortened to reduce overall costs and the occurrence of reworks or change orders. Traditional approaches, such as completing the design before construction, no longer meet client needs due to inherent delays and cost overruns (Sobotie, 2004).

Construction projects involving multiple participants and long prediction cycles are prone to errors that lead to rework, contributing to cost overruns and time delays in Nigeria (Aje, 2008). Insufficient interaction among design and construction, suboptimal solutions, and a high number of change orders are identified as significant problems leading to rework. Rework, stemming from defects in the design or construction process, has been recognized as a major issue in the Nigerian construction industry, resulting in more losses than other factors on construction sites (Kaming et al., 1997).

Rework significantly impacts project success or failure, causing cost escalation, delays, reduced productivity, and client dissatisfaction, ultimately leading to reduced profitability and potential litigation (Love et al., 1998). The design phase of building projects is crucial, but often lacks interaction between construction and design teams, leading to problems such as incomplete designs, change orders, rework, and construction delays (Alarcon, 1998). The complex nature of construction activities globally has led to an increase in cost, project delivery delays, and poor customer satisfaction, with rework playing a significant role (Ayetan, 2013). Rework originates from the identification of defects and changes in requirements, impacting project cost, scheduling, and productivity. Therefore, effectively reducing rework is crucial for construction project success (Forcade et al., 2017).

Rework in Construction Projects

The construction industry is often plagued by cost and schedule overruns, with rework emerging as a significant factor contributing to these challenges (Kermanshachi, 2016). Rework, characterized by work that must be redone due to failure to achieve the desired results, has been observed to impact construction efficiency, labor productivity, and project performance (Thomas, 1995).

Various causes of rework have been identified, including design changes, material supply issues, client-directed changes, project communication, and subcontractor performance (Love et al., 2009). Quality management has also been recognized as a primary cause of rework, as failures to achieve the desired level of quality during initial project execution often lead to rework. The root causes of rework is essential for optimizing construction performance (Palaneeswaran, 2006) and effectively minimizing its impact on projects (Dissanayake, 2003).

Rework has been the subject of extensive research, with efforts focused on identifying its causation factors and their influence on project cost and schedule performance (Hwang et al., 2009). Design-related factors, client-related factors, and contractor-related factors have been identified as key contributors to rework, emphasizing the need for effective quality management, value engineering, and proactive rework evaluation and management practices (Kermanshachi, 2016).

The frequent occurrence of rework in complex projects poses significant challenges and can lead to substantial cost overruns and schedule delays. Researchers have proposed various strategies and management tools to improve construction efficiency and prevent potential reworks (Kermanshachi et al.,2016). Addressing the multifaceted nature of modern construction projects and implementing stricter rework appraisal and management practices are crucial for mitigating cost overruns and schedule delays (Zaneldin, 2000).

In-depth studies have focused on classifying and understanding the causes of rework, identifying specific factors that influence rework, and proposing strategies to enhance construction work zones and prevent potential reworks in complex projects (Kermanshachi et al., 2016). The identification of design-related, client-related, and contractor-related factors as key contributors to rework highlights the need for effective quality management and proactive measures to minimize rework and its adverse impact on construction projects.

Rework Impact on Project Performance

The impact of rework on project performance varies depending on when it occurs in the construction process. Rework, defined as the act of performing a task more than once, can happen at different stages throughout the project life cycle. Fayek et al. (2004) asserts that rework significantly affects project performance and the ability to complete projects within time and cost constraints. Rework has a substantial impact on the industry as a whole, both directly and indirectly.

Several consequences of rework on project delivery have been identified, including time overruns, cost overruns, client and contractor dissatisfaction, demotivation, and poor contract management. Studies on various construction projects have shown that rework can account for a significant portion of the total project cost and time. For example, in a study of seven Swedish construction projects, it was found that about 4.4% of the total project cost was spent on rework, and an additional 7.1% of total work time was needed to cover that (Josephson, 2012).

The detrimental effects of rework are not limited to specific regions or types of projects. Various studies conducted in both developed and developing countries have consistently highlighted rework as a significant contributor to cost and schedule overruns in construction and engineering projects. Rework has also been linked to other negative consequences such as reduced profit, damaged reputation, increased turnover, lower productivity, higher costs, and potential litigation. It has been estimated that the costs of reworks can range from 5% to 20% of the contract value, and poorly managed projects can experience even higher costs (Ahmed and Naik, 2016; Barber et al., 2000).

Latent conditions within organizational and project systems have been identified as significant contributors to rework. These latent conditions, including errors, violations, and unidentified problems, can have a substantial impact on project performance and productivity, potentially leading to safety hazards and accidents.

Research Methodology

This study developed a research design considering factors such as information acquisition methods, problem nature, and available resources. A clear statement of the research problem, procedures for gathering information, population to study, and data processing methods are essential. A five-step methodology will be implemented, identifying causes of rework through literature review, collecting data through a structured survey among Subject Matter Experts (SMEs), conducting descriptive data analysis, constructing identification using EFA, and developing a Structural Equation Model (SEM) using the AMOS statistical computer program. This will help understand the interrelationship among rework indicators and provide valuable insights into the research process.

Population and Sample Size

The research gathered information from contractors who executed the TETFUND building project in four Nigerian states, specifically Kaduna, Niger, Kogi, and FCT. The sampling technique used was purposive sampling, as it allowed for the selection of specific units of the universe to represent the total population. This method was chosen due to the advantage of having experts' opinions supporting decisions made.

Determining an appropriate sample size poses a common challenge, particularly for students and early-stage researchers, due to the need for statistically reliable estimates. While random sampling requires rigorous statistical justification, purposive sampling allows for a more judgment-based approach where representativeness is derived from expert selection rather than probability. Literature suggests that for studies using purposive sampling, sample sizes between 100 and 400 can still yield meaningful and stable parameter estimates (Iacobucci, 2009). Although there are no universally fixed rules, recommendations generally propose a minimum of 50 to 100 respondents depending on the study scope and population accessibility. In line with these guidelines, this study's sample size of 133 was deemed sufficient to ensure credible results, particularly within the qualitative bounds and targeted nature of purposive sampling.

Data Collection

This study employed a structured questionnaire to gather standardized responses from participants, enabling comparative analysis using a five-point Likert scale. The Likert scale was selected for its effectiveness in enhancing response accuracy, maintaining respondent engagement, and reducing survey fatigue. It has been widely adopted in construction research, particularly in studies exploring causative factors of rework.

The questionnaire was developed based on an extensive review of relevant literature to capture all possible latent conditions associated with rework in construction projects. It was divided into two sections: **Section A** gathered demographic and professional background information of respondents, while **Section B** addressed the core research objectives, asking participants to rate their level of agreement with each rework factor on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

Distribution of the questionnaire employed a purposive sampling approach, targeting experienced professionals within the construction industry. Questionnaires were shared both manually (through one-on-one distribution in professional settings) and electronically via email and online forms. A total of 160 questionnaires were distributed, out of which 133 were completed and returned, representing a response rate of 83.1%, which is considered adequate for reliable data analysis in purposively sampled studies.

Data Analysis

The study utilized descriptive and inferential analysis to analyze data from a questionnaire survey. A Structural Equation Model (SEM) was developed using AMOS software to examine the structural relationship between measured variables and latent constructs. SEM is a multivariate analysis method that combines factor analysis and path analysis to examine causal relationships in social sciences. It has been used in various domains of construction management, including trust, organizational justice, flexibility, success traits, delay factors, and safety performance.

Results and Discussion

Table 1: General Information about Respondents

S/N	Features	Parameters	Frequency	Percentage (%)
1	Size of firm	Small	28	21.05
		Medium	73	54.89
		Large	32	24.06
			133	100.00
2	Working Experience	Less than 5 years	7	5.26
		6 - 10 years	22	16.54
		11 - 15 years	42	31.58
		16 - 20 years	39	29.32
		Exceeding 20 years	23	17.29
			133	100.00
3	Academic Qualification	HND/B.Sc	78	58.65
		M.Sc	53	39.85
		Ph.D	2	1.50
			133	100.00
4	Rank	Strategic	43	32.33
		Managerial	74	55.64
		Operational	16	12.03
			133	100.00
5	Professional Status	Probation	12	9.02
		Member	95	71.43
		Associate	22	16.54
		Fellow	4	3.01
			133	100.00
6	Project Type	Lecture Theatre	30	22.56
		Block of Office/Classroom	45	33.83
		Library	20	15.04
		Hostel	27	20.30
		Laboratory	11	8.27
			133	100.00

Table 1 discussed that, a total of 133 valid responses were analyzed. Of these, 21.05% operated in small-sized firms, 54.89% in medium-sized firms, and 24.06% in large-sized firms. In terms of professional experience, 5.26% had less than 5 years, 16.54% had 6–10 years, 31.58% had 11–15 years, 29.32% had 16–20 years, and 17.29% had over 20 years of experience.

Regarding educational qualifications, 58.65% held HND/B.Sc., 39.85% had M.Sc., and 1.50% held Ph.D. degrees. For job roles, 32.33% were in strategic positions, 55.64% in managerial roles, and 12.03% at the operational level.

On professional affiliations, 9.02% were probationers, 71.43% were full members, 16.54% were associates, and 3.01% were fellows. Project types represented included lecture theatres (22.56%), office/classroom blocks (33.83%), libraries (15.04%), hostels (20.30%), and laboratories (8.27%).

The responses reflect a well-qualified and experienced sample relevant to the study objectives. Data analysis was conducted using SPSS Version 23.0, and the survey took place between August and September 2021.

Table 2: Factor Analysis: Component Extraction and Total Variance

To identify and group the underlying constructs influencing construction project scheduling processes, a factor analysis was conducted. The aim was to reduce the large set of interrelated variables into fewer meaningful components, allowing for better interpretation and understanding of the key drivers. Principal Component Analysis (PCA) with Varimax rotation was used as the extraction method to achieve clearer component loading and enhance interpretability of the results.

Components	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.611	28.704	28.704	8.611	28.704	28.704	4.061	13.538	13.538
2	3.720	12.400	41.104	3.720	12.400	41.104	3.800	12.666	26.204
3	2.272	7.573	48.677	2.272	7.573	48.677	3.255	10.849	37.053
4	1.858	6.194	54.871	1.858	6.194	54.871	2.854	9.514	46.567
5	1.507	5.025	59.896	1.507	5.025	59.896	2.701	9.004	55.571
6	1.152	3.841	63.737	1.152	3.841	63.737	2.450	8.166	63.737

The factor extraction process followed the Kaiser criterion, which recommends retaining components with eigenvalues greater than 1. As shown in Table 2, six components met this criterion. These six components collectively accounted for 63.737% of the total variance, thus satisfying Pallant's (2007) recommendation that retained factors should explain at least 50% of the total variance to be considered meaningful in social science research.

The initial eigenvalue for Component 1 was 8.611, explaining 28.704% of the total variance, followed by Component 2 with 12.400%, and subsequent components each contributing decreasing but relevant percentages to the total variance explained. The Rotation Sums of Squared Loadings show improved distribution of variance among the six retained factors, with Component 1 now accounting for 13.538%, and Component 6 contributing 8.166%. This balanced spread indicates a more interpretable structure, supporting the use of rotated components for further analysis.

In line with Pallant (2007), the scree plot and component matrix were also examined to confirm the number of components to retain, affirming the extraction of six key components for deeper interpretation and subsequent discussion.

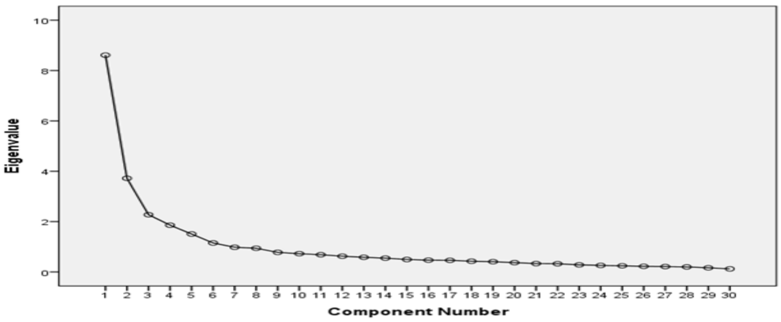


Figure 1: Scree Plot

Table 3: Rotated Component Matrix

Variables	Component[a]					
	F1	F2	F3	F4	F5	F6
V30:Competitive tendering	0.775					
V35:Socio cultural factors	0.721					
V46:Traditional procurement method	0.709					
V56:Lack of contracting strategy	0.702					
V28:Adversarial attitudes	0.676					
V32: Pressure to start work	0.643					
V12:Poor coordination		0.794				
V1:Lack of supervision		0.782				
V18:Poor project management by contractor		0.747				
V4:Poor strategy and leadership		0.674				
V21:Lack of knowledge management		0.595				
V7: Design change		0.516				
V37: Mistake and defect in design			0.790			

V26: Wrong initial budget			0.673			
V27: Low speed in decision making			0.668			
V39: Incomplete design information			0.664			
V48: Modification made by owner			0.563			
V25: Poor scope definition			0.517			
V42: Unavailability of equipment				0.864		
V43:Low productivity of equipment				0.767		
V44: Replacement of material				0.673		
V65: Accountability					0.729	
V66: Well-being					0.693	
V67: Cognitive dissonance					0.648	
V59: Personality type					0.621	
V62: Misinterpretation due to lack of knowledge					0.543	
V50: Wrong material selection						0.690
V55: Lack of adherence of quality control						0.682
V53: Discrepancies between the admin and man. Team						0.608
V54: Inadequate interface management						0.601

[a]. Rotation converged in 8 iterations.

Table 3 presents the interpretation and naming of the six components extracted through factor analysis, based on the significant loading of variables on each factor. The first factor, Contractor-Related Conditions, accounts for the largest percentage of variance explained (as shown in Table 2). Key variables loading under this factor include competitive tendering, socio-cultural influences, use of traditional procurement methods, absence of contracting strategy, adversarial relationships, and premature commencement of work.

The second factor, Coordination and Supervision-Related Conditions, represents the next largest share of variance (referenced in Figure 1), with significant variables such as poor coordination, inadequate supervision, weak project management by contractors, ineffective leadership strategies, and lack of structured knowledge management practices.

Design and Organizational Conditions form the third component, also explaining a substantial portion of variance (as shown in Figure 1). This factor comprises variables that highlight weaknesses in design planning and organizational structure. The fourth component, Capital Asset-Related Conditions, also contributes significantly to the overall variance (as shown in Table 2), and includes key issues such as equipment unavailability, low equipment productivity, and delays due to material replacement.

The fifth component,People-Related Conditions, accounts for the smallest share of explained variance (refer to Table 2). Variables significantly loading under this factor include incorrect material selection, poor adherence to quality control standards, misalignment between administrative and management teams, and inadequate interface management between consultants and contractors.

Together, these six components provide a robust framework for understanding the latent conditions influencing construction project performance, as uncovered through the factor analysis.

Measurement Model

Structural Equation Model (SEM)

The Structural Emissions Modeling (SEM) method is a statistical analysis technique used to study the relationships between variables in a system. It consists of measurement and structural components, with the former focusing on the representation of latent variables by observed variables, and the latter on multiple regression analysis and path analysis.

The SEM is typically developed through three steps: defining the components, verifying the model, and interpreting it. In this study, the study selected six latent variables and 29 measurable variables from the PCA results. Three construction management professionals were interviewed to make assumptions about the interrelationships among the components. A series of literature analysis was conducted to improve the assumption-making process. The study hypothesized 15 relationships for the structural model, including coordination/ supervision, contractor, design/organizational, capital assets, people, project, and capital assets.

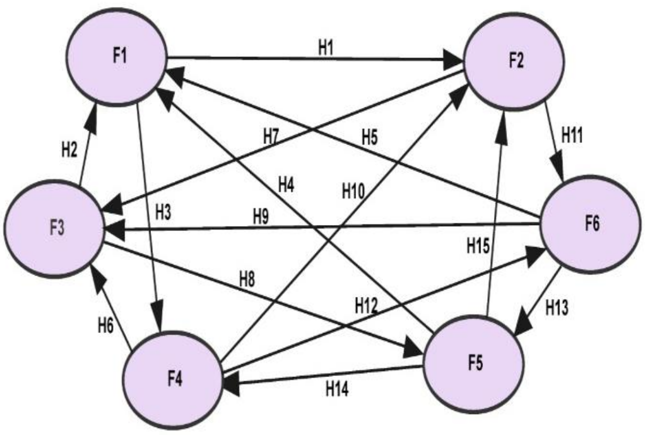


Figure 2: Hypothetical structural model

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis was conducted to check the properties of the instrument items prior to analysing the structural model. After grouping of the attributes, a conceptual measurement model was developed to test the relationship among the latent conditions of rework causes of construction project as shown in Fig 4.3. The model connects the variables and the constructs based on the theories earlier discussed. The study evaluates the outer model (measurement model) in a reflective indicator. The reflective indicator combines all possible connections within the construct and is related to a construct through factor loadings (Hair et al., 2014).

Confirmatory factor analysis (CFA) based on AMOS 23.0 was conducted to first consider the measurement model fit and then assess the reliability, convergent validity and discriminant validity of the constructs (Arbuckle, 2009).

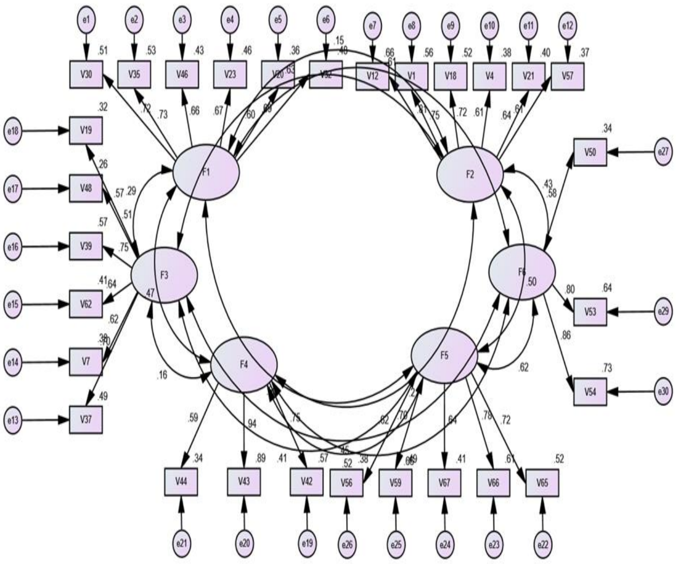


Figure 3: Conceptual measurement model

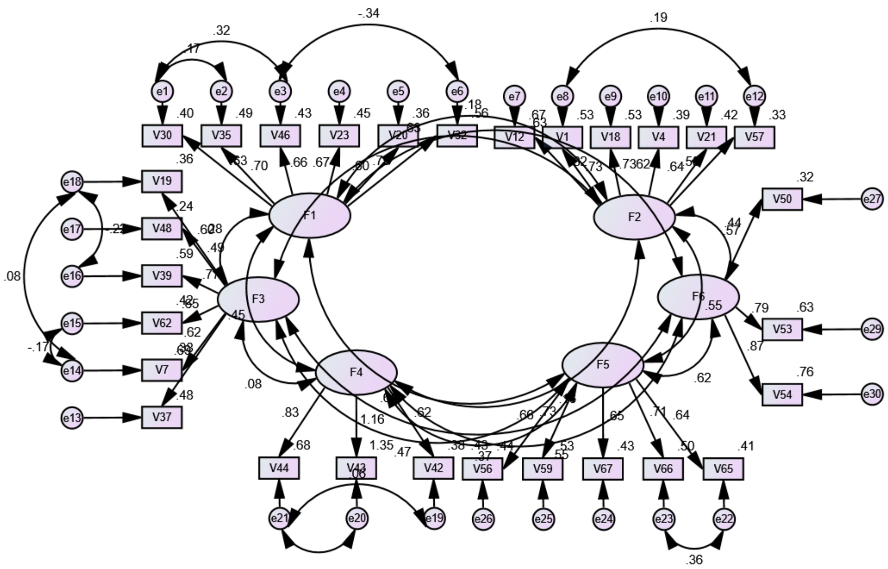
Evaluation of Measurement Model

Goodness of fit indices (GOF) are used to assess the appropriateness of measurement models in statistical machine learning (SEM). These measures are independent of sample size, accurate, and consistent in evaluating dissimilarity models. Unegbu et al. (2020) established that the GOF index is measured by the Chi-square degree of freedom ratio (X2/df), an absolute fit index. Other measures include the non-normed fit index (NNFI or TLI), the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMSR). These measures help determine the overall fit of a model and its fitness. A good fit is indicated by a value less than 3 and a correlation between the proposed model and an independent model.

Table 4: Summary of error covariance added to structural model run

	X^2/df	GFI	CFI	TLI	RMSEA	SRMSR
Initial model	3.143	0.612	0.613	0.623	0.10	0.100
Add e1 to e2 and e3	3.095	0.619	0.652	0.630	0.990	0.990
Add e3 to e6	3.079	0.629	0.661	0.638	0.990	0.990
Add e8 to e12	3.013	0.595	0.630	0.608	0.980	0.980
Add e14 to e15	3.00	0.746	0.764	0.736	0.960	0.097
Add e16 to e14 and e18	2.923	0.770	0.765	0.794	0.091	0.095
Add e21 to e19 and e20	2.714	0.774	0.768	0.799	0.090	0.094
Add 22 to e23	2.687	0.790	0.784	0.812	0.084	0.090

The table revealed the hypothetical model's GOF measures showed that it was insufficient to explain the interrelationships among constructs, requiring revision. Two methods were suggested: using the modification index provided by the Amos computing tool in SPSS to add causal relationships, and deleting a path showing a low causal relationship. Modification indexes can be used to modify model specifications to enhance fitness. Table 4 shows no significant reductions in Chi-Square derived from new structural relationships, but some reductions were expected due to adding covariances among indicators. The model can be stable without additional error covariance. The structural model's assessment of modification indices can help enhance the goodness of fit in the measurement model.



Fugue 4: Revised measurement model

The hypothetical model underwent revisions to improve its appropriateness and validity, with significant improvements in X2⁄df, TLI, CFI, and RMSEA. Construct validity was assessed using convergent and discriminant validities, with CB composite reliability (CR) being preferred over Cronbach's alpha values for internal consistency. Construct validity measures variables reflecting latent constructs, established by convergent and discriminant validity.

Convergent Validity

Convergent validity measures the convergence of multiple items used in measuring a construct. Factor loading and average variance extracted (AVE) are crucial for assessing validity. Chin (2010) recommends a CR value above 0.7 for all constructs. Fornell and Larcker (1981) suggest that if AVE is less than 0.5 but CR is higher than 0.6, the construct's convergent validity is satisfactory.

Table 5: Model Validity Measures

	CR	AVE	MSV	MaxR(H)	F1	F2	F3	F4	F5	F6
F1	0.835	0.458	0.388	0.839	0.677					
F2	0.844	0.478	0.383	0.860	0.167	0.691				
F3	0.800	0.404	0.383	0.815	0.289	0.619	0.636			
F4	0.922	0.807	0.302	-103.389	0.443	0.161	0.087	0.899		
F5	0.810	0.461	0.390	0.813	0.597	0.552	0.476	0.376	0.679	
F6	0.794	0.569	0.390	0.842	0.623	0.438	0.435	0.550	0.624	0.754

Path Model

Path analysis is a subset of structural equation modeling that examines relationships between independent and dependent variables. This research used AMOS 23.0.0 software to analyze the primary hypothesized model, which satisfied the suggested cut-off points after three iterations. The goodness of fit (GOF) indicators were standardized to ensure comparable coefficients. Standardized path coefficients were used to assess causal paths and statistical significance.

The CFA phase involved replacing correlations between constructs with hypothesized causal relationships. Fifteen hypotheses were given to build the hypothetical structural model, with arrows indicating the direction of hypothesized influence. The statistical significance of the standardized paths was determined to be at least 0.20 and preferably more than 0.30 for significant debate.

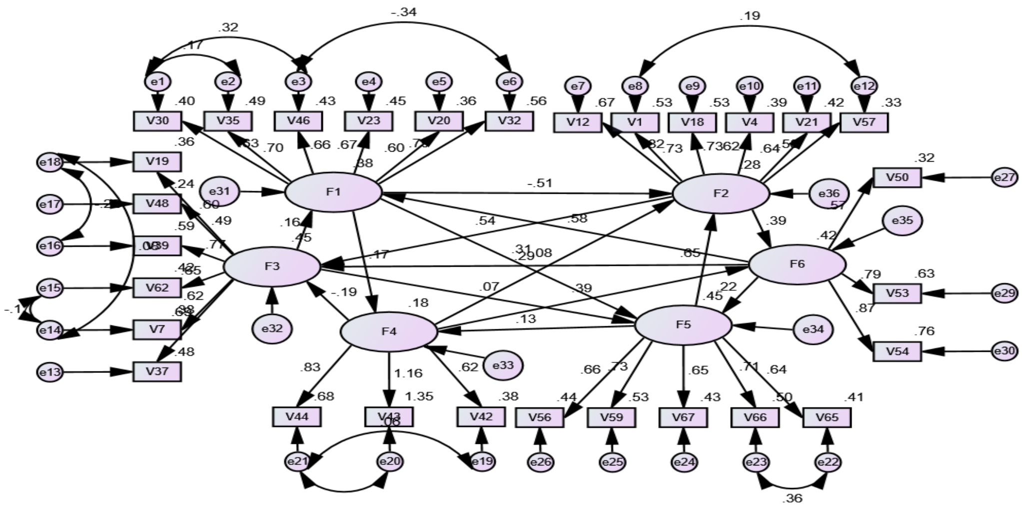


Figure 5: Final Structural Equation Modeling of the Interrelations between Latent Conditions of Rework Causes

Table 6: Hypothesis Testing

Path				Estimate (β)	T value	P Value	Validated	Rejected	Changed
Direct Effect									
F2	<--	F1	H_1	-0.513	-2.421	0.015			Yes
F1	<--	F3	H_2	0.160	1.367	0.172NS*		Yes	
F4	<--	F1	H_3	0.174	1.559	0.119 NS*		Yes	
F5	<--	F1	H_4	0.316	2.591	0.010	Yes		
F1	<--	F6	H_5	0.581	4.282	0.000	Yes		
F3	<--	F4	H_6	-0.194	-3.043	0.002			Yes
F3	<--	F2	H_7	0.547	4.812	0.000	Yes		
F5	<--	F3	H_8	0.072	0.542	0.588 NS*		Yes	
F3	<--	F6	H_9	0.294	2.887	0.004	Yes		
F2	<--	F4	H_{10}	0.095	1.025	0.306 NS*		Yes	
F6	<--	F2	H_{11}	0.390	2.922	0.003	Yes		
F6	<--	F4	H_{12}	0.398	4.885	0.000	Yes		
F5	<--	F6	H_{13}	0.228	1.578	0.114 NS*		Yes	
F4	<--	F5	H_{14}	0.132	1.293	0.196 NS*		Yes	
F2	<--	F5	H_{15}	0.654	3.73	0.000	Yes		

Table 6 SEM analysis revealed a positive relationship between coordination/supervision and people related conditions, contractor and project related conditions, design/organizational and project related conditions, project related conditions related factors and capital assets related conditions, and people related conditions and contractor related conditions. However, the model rejected hypotheses between contractor and design/organizational related conditions, capital assets related conditions and contractor related factors, people related conditions and design/organizational related conditions, and

coordination/supervision related conditions and contractor related conditions. The model also changed the negative to positive hypothesis for these conditions.

Discussion of the Interrelationships amongst Causes of Rework

The study analyzed the relationship between people-relate conditions, project-related conditions, contractor-related conditions, and project-related conditions in a project. The results showed that people-related conditions have a direct positive influence on coordination/supervision-related conditions, project-related conditions have a direct positive influence on contractor-related conditions, and project-related conditions have a direct positive effect on people-related conditions. However, two hypotheses, 'contractor-related conditions' and 'capital assets-related conditions', were changed from direct influence to negative influence due to their negative path coefficient values.

The study found that coordination issues have the highest path coefficient of 0.58, indicating the most significant impact on rework. Poor contract execution was the second most important parameter, followed by client issues, consultant issues, and worker issues. In developing countries like Nigeria, improper site management and project communication were the second and third critical reasons for rework, respectively. The study validated the interrelationships between these causes of rework based on the collected data. The results suggest that people-related conditions have a direct positive influence on coordination/supervision-related conditions and contractor-related conditions have positive impacts on project-related conditions.

Conclusion and Recommendations

The study presents a structural model to understand the criticality of causes contributing to rework in building construction projects. A survey of 133 construction firms was conducted using a questionnaire with 67 items on a 5-point Likert scale. The 67 attributes were grouped into six components: contractor related conditions, coordination/supervision relatconditions, design/organizational related conditions, capital assets related conditions, people related conditions, and project related conditions. The study found that coordination/supervision related conditions are significantly influenced by people related conditions as the most critical cause of rework. The influence of contractor related conditions to project related conditions was also studied using PCA.

Based on the findings and validated structural relationships identified through SEM, the study recommends that construction firms prioritize strengthening coordination and supervision mechanisms, as these are significantly influenced by people-related factors such as skill level, communication, and team dynamics. Improving supervision and knowledge management frameworks can help reduce rework by addressing core coordination challenges.

Furthermore, contractor-related conditions such as procurement strategy, organizational culture, and tendering processes should be reviewed and aligned with project goals to minimize project-related complications. Emphasis should be placed on improving contractor oversight, strategic leadership, and project planning to reduce instances of rework. Lastly, design processes must be refined through iterative review mechanisms and enhanced integration between design and construction teams to prevent errors at early project stages.

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