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Risk Mitigation Model for Addressing Contractual Claims Risk in Civil Infrastructure Projects in South Africa

Awad Saad [1], Lance Wentzel [2,*], Julius Ayodeji Fapohunda [2] and Rainer Haldenwang [1]

[1] Department of Civil Engineering and Geomatics, Cape Peninsula University of Technology, Bellville 7530, South Africa; awadsaad203@gmail.com (A.S.); haldenwangr@cput.ac.za (R.H.)
[2] Department of Construction Management and Quantity Surveying, Cape Peninsula University of Technology, Bellville 7530, South Africa; bldrfapo@gmail.com
* Correspondence: wentzell@cput.ac.za; Tel.: +27-72-283-5398

Abstract: The risks arising from contractual claims in the civil engineering construction industry in South Africa are a concern. Currently, there are no risk mitigation models available for managers to help reduce such risks. A theoretical risk mitigation model was developed from the literature and validated through partial least squares structural equation modelling (PLS-SEM), using primary questionnaire data obtained from 166 respondents drawn from a pool of South African construction industry professionals, including project directors, project managers, supervisors, consultants, and contractors. The descriptive results indicate significant patterns, trends, and distributions of the variables across the three constructs in the study. The PLS-SEM results indicate that factors causing contractual claims risk in civil infrastructure projects have a significant relation to the impact of risk occurrence on these projects, influencing the strategies to be implemented to mitigate such risks. The PLS-SEM results also indicate a significant direct relation between the factors causing contractual claims risk and the strategies to be implemented to mitigate risks, thus implying that the holistic adaptation of the PLS-SEM (risk mitigation model) by construction industry professionals in South Africa should reduce contractual claims risk in civil infrastructure projects. The findings serve as a valuable guide not only to construction industry professionals but also to government agencies such as the Department of Public Works and Infrastructure.

Keywords: civil infrastructure projects; contractual claims risk; risk occurrence; South Africa

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1. Introduction

The construction industry is an important sector of economies globally, enhancing and contributing to the development of nations [1,2]. In South Africa, the construction industry is a key pillar of the National Development Plan, providing civil infrastructure projects that support economic growth [3]. Noting this, investing in civil infrastructure projects provides the opportunity for vital services that support society and cultivate sustainable economic growth [4–6]. Hence, large budgets are allocated for infrastructural development by the government, ensuring progress in the provision of civil infrastructure projects [7]. The process of implementing such projects consists of several stages, including initial planning, detailed design, construction, and ongoing maintenance, all of which contribute to creating sustainable infrastructure that meets the needs of society [8].

Civil infrastructure projects are known to be complex and multifaceted by nature and are vulnerable to a wide range of risks that impede project delivery [9,10]. In recent years, these projects have faced many challenges related to contractual claims risk, defined

as a potential threat that impedes the progress of a project as a result of failure to fulfil legal agreements between contracting parties [11], including higher construction costs, litigation, quarrelling, disputes between contractual parties, and abandonment of projects, all of which negatively impact project delivery [12–14]. These challenges are also related to technical complexities, financial constraints, regulatory barriers, and socio-political factors that require urgent interventions [15,16].

Noting these challenges, the construction industry has developed several risk management methods and procedures (such as risk identification, risk assessment, risk allocation, and risk monitoring and control) to enhance project performance [17,18] These methods are, however, insufficient to mitigate contractual claims risk [19,20]. Studies by Ikuabe et al. [21] have been conducted in South Africa, indicating that no agreement has been attained between researchers and construction industry practitioners regarding key factors and practices in risk assessment and the choice of appropriate techniques to develop a risk management model that could help mitigate and enhance the performance of construction project metrics. To support the above, Safapour et al. [22] suggested that there is a need for the mitigation of risks associated with cost increments during construction project delivery, with the objective of avoiding the wastage of public funds generated from tax revenue budgeted for these projects. There is therefore a need to establish a model to reduce claims and risks that often result in high construction costs [23], highlighting the importance of a structured approach to effectively identify, assess, and mitigate risks in civil infrastructure projects [24].

This study therefore aimed to develop a risk-mitigation model to guide the effective mitigation of contractual claims risks facing the delivery of civil infrastructure projects in South Africa by focusing on the following risk-related factors and their hypothetical relationships:

- The causes of contractual claims risks pertaining to the delivery of civil infrastructure projects in South Africa;
- The impacts of risk occurrence on the delivery of civil infrastructure projects in South Africa;
- Mitigating strategies to address risks influencing the delivery of civil infrastructure projects in South Africa.

These elements were identified in the literature review and validated in the form of an online questionnaire survey and structured interviews. The relationships between the elements were tested and the final inclusion of elements was then validated using PLS-SEM.

2. Literature Review

2.1. Causes of Contractual Claims Risk in Civil Infrastructure Project Delivery

2.1.1. Client-Related Causes

Alshihri et al. [25] categorised client-related risk factors contributing to delays in the completion of construction projects and identified the three most significant risk factors as delays in making progress payments for completed work, awarding contracts to the lowest bidder, and change orders during construction. Similarly, Qershi and Kishore [26] stated that excessive change orders by the client and slow decision-making by the client were the two most important factors contributing to the generation of claims in construction projects. In addition, Gamage and Kumar [27] identified several major causes: unrealistic client expectations, untimely payments, the client's lack of knowledge, slow client responses, poor communication and cooperation between the owner, consultant, and contractor, tender pricing, and changes to the scope of work.

2.1.2. Contractor-Related Causes

Alshihri et al. [25] identified the key factors leading to completion delays and cost overruns in construction projects as the contractor's financial difficulties, ineffective project planning and scheduling, manpower shortages, and poor site management and supervision by the contractor. Gamage et al. [27] also pointed out other contributing factors associated with contractors, including failure to comply with contractual obligations, limitations in the project manager's authority, inefficiencies in the expertise of project participants, differences in individual interests, inefficiencies in training, employee-related issues, omissions, poor construction performance, poor communication, lack of confidence between the contractor and employer, incomplete claims with poor substantiation, poorly drafted claims, failure to comply with contractual obligations, differences in individual interests, lack of training, and unclear risk allocation.

2.1.3. Consultant-Related Causes

The major consultant-related causes include contractual matters, quality of contract content, errors in contract documents, non-serviceable contract information, type of contract, complexity of contract documents, unforeseen issues between stakeholders related to contract conditions, poor contract administration, unrealistic estimations, errors in design data and design documents, incomplete designs, design errors, project award criteria, uneven responsibilities and obligations towards project completion, project schedule and errors in initial estimates, unclear risk allocation, discrepancies in bills of quantities, and misinterpretation of client requirements [27].

2.1.4. External Causes

Several common causes of contractual claims risks in civil infrastructure projects have been identified, including lack of communication, insufficient planning, poor specifications, unclear contracts, poor construction site conditions, late payment, manpower restrictions, poor-quality materials and equipment, lack of supervision, acceleration measures, delays, lack of notice requirements, and changes in construction design by the owner. These factors often lead to disputes among construction stakeholders, particularly between the client and the contractor [28].

Insufficient risk allocation strategies in contracts regularly lead to disputes and claims [29]. Similarly, inappropriate risk allocation, particularly in traditional contracting models, plays an influential role in the high occurrence of claims in infrastructure projects, while inadequate quality control and workmanship concerns further contribute to the risk of contractual claims [30]. Change or variation orders resulting from new client requirements, discrepancies in quantity estimations, delays caused by contractors, design errors or omissions, and inconsistencies in drawings and specifications are substantial contributors to claims in construction projects [31]. Lack of experience, inadequate technical knowledge, poor decision-making, and ineffective project management among project team members contribute to contractual claims risk, as stated by Abdelalim et al. [32].

The six most significant risk factors have been identified as a shortage of skilled personnel, resistance to change, limited knowledge and experience, challenges in model management, the absence of clear guidelines for contractual agreements, and liability-related concerns [33]. Regulatory changes and compliance issues are significant risk factors in infrastructure projects, often resulting in claims for additional time and costs [34].

2.1.5. Finance-Related Causes

According to KV and Bhat [35] the most critical finance-related causes include delays in the settlement of claims, the contractor's financial difficulties, delays in payment for extra

work or variations by the owner, late payments from the contractor to subcontractors or suppliers, variation orders or scope changes by the owner during construction, and design changes initiated by the owner. Financial issues and payment delays are also significant causes of contractual claims risks. Late payments or financial difficulties experienced by any of the project stakeholders lead to cash flow problems, work stoppages, and subsequent claims [36]. This is supported by Gunduz and Elsherbeny [37], who stated that payment-related issues, including delayed payments and under-certification of work, are major contributors to contractual claims in construction projects. Regulatory and compliance issues also impact contractual claims risk. These refer to, among other things: changes in regulations, permit delays, and non-compliance with environmental or safety requirements, which can negatively impact the project, causing project disruptions and claims.

2.1.6. Contractual Risk Factors

According to Sikhupelo and Amoah [38], contractual risk factors in construction project delivery can be classified into two main categories: internal and external risk factors.

- Internal risk factors include:

Project department-related risks, such as budget cuts, lack of synergy between departments, poor project implementation planning, delayed appointment of service providers, frequent scope changes, inadequate financial planning, limited capital availability, payment delays, late project completion, and a shortage of skilled human resources.

Risks related to project consultants and managers, including poor contract management, ineffective implementing agents, lack of experienced personnel, inadequate health and safety management, weak project management practices, insufficient planning, the use of unapproved designs, and poor risk identification processes.

Corruption-related risks, such as the mismanagement of funds, fraudulent practices, irregularities in the appointment process, and poor procurement practices.

Political interference-related risks, which may involve intervention by municipal or provincial authorities, interference in labour engagement, and undue influence over the appointment of contractors and consultants.

- External risk factors include:

Community-related risks, such as disruptions caused by business forums, challenges from construction mafias, general community unrest, lack of community involvement and consultation, and strikes by workers.

Material-related risks, including material scarcity and delays in the supply of materials.

Unforeseen events-related risks, such as unfavourable soil conditions, delays in verifying appointment letters, natural disasters, site incidents, environmental challenges, and geological events.

Contractor-related risks, which include poor contractor performance, inaccurate tender pricing, lack of skilled subcontractors, contractor incompetence, poor cash flow management, substandard workmanship, lack of experience and capacity, limited financial resources, non-compliance with health and safety standards on-site, a shortage of skilled labour, CIDB grading challenges, and contractor liquidation.

2.2. Impact of Contractual Claims Risk in Civil Infrastructure Project Delivery

2.2.1. Risk Occurrence

Risk occurrence in civil infrastructure projects is influenced by a variety of factors. These include increased project complexity; unclear or incomplete project scope; difficulty in assessing site conditions and attributes; rising project costs; financial or funding hardships; inaccurate cost and schedule predictions; inability to support fast-tracked delivery;

ineffective change management, ineffective dispute resolution and claims management; ineffective safety management; ineffective risk management; ineffective quality management; and ineffective sustainability management [39].

In addition to these factors, Khalef and El-Adaway [39] also identified improper or absent implementation of value engineering; inappropriate contractor selection or pricing agreement methods; inadequate use of innovative construction methods; lack of contractor incentives; low team collaboration and poor team culture; ineffective or inappropriate organisational structures; low stakeholder experience and poor stakeholder relationships; low owner satisfaction and involvement; and insufficient in-house capacity.

They also highlighted the lack of regular meetings and project monitoring, ineffective project documentation, limited use of constructability reviews, regulatory restrictions, adverse market conditions, and negative impacts on surrounding areas as significant contributors to the risks encountered in such projects [39].

2.2.2. Risk Effects on Project Delivery

Risks significantly affect the delivery of civil infrastructure projects by causing delays, cost overruns, and quality issues, ultimately hindering overall project success. These risks can originate from various sources, including poor planning, design errors, financial instability, and incompetence within the project team [40]. Force majeure events can result in claims for extensions of time and additional project costs [34]. Furthermore, such events, including natural disasters, pandemics, or political instability, exacerbate the risk of contractual claims, as they are typically beyond the control of project stakeholders, thereby disrupting project progress [41]. Ahmed et al. [42] highlighted that unanticipated ground conditions and geotechnical issues pose significant risks in infrastructure project delivery.

2.2.3. Risk Effects on Time and Cost Performance

Aljohani et al. [43] identified the main risk factors contributing to time and cost overruns in construction projects as frequent design changes, contractors' financing issues, payment delays for completed work, lack of contractor experience, poor cost estimation, inadequate tender documentation, and ineffective materials management. In addition to these factors, Alawneh et al. [44] highlighted that original design changes, inaccurate budgeting due to inexperience, additional material and equipment expenditures, inadequate design information, insufficient client funding, poor project planning, tight project schedules, and inadequate identification of the construction scope are among the top-scoring risks impacting the time and cost performance of construction projects.

2.2.4. Frequency of Contractual Claims

Kumar et al. [45] stated that vague clauses in contracts as well as discrepancies between different contract documents are two major causes of claims in highway projects and can result in contradictory interpretations of project requirements, scope, and responsibilities, which can ultimately lead to claims. Design errors and omissions are also frequent sources of contractual claims in civil infrastructure projects that contribute significantly to rework, delays, and additional costs. According to Dosumu and Aigbavboa [46], design-related issues, which include errors, omissions, and inconsistencies, are some of the top causes of claims in public construction projects. Unanticipated site conditions are also a common cause of contractual claims, particularly in projects that involve extensive earthworks or underground construction, leading to delays, additional work, and increased costs [47]. The scarcity of capital resources and unforeseen site conditions can also create grounds for disputes [27].

2.3. Risk Mitigation Strategies for Civil Infrastructure Project Delivery

2.3.1. Client-Related Strategies

Iqbal et al. [48] asserted that clients play a pivotal role in managing risks within construction projects, specifically through strategies that ensure financial resources, address design document issues, manage changes in codes and regulations, and define the scope of work to improve overall construction project management, including, among others, civil infrastructure project delivery. Similarly, Amoah and Nkosazana [49] highlighted the importance of involving experienced contractors and consultants during project implementation to reduce risks and secure construction guarantees.

Habetemeherit et al. [50] identified client-related causes of contract terminations in public construction projects and recommended solutions such as effective contract management, early risk assessment, and collaborative project management to reduce delays and financial losses. Mitchell [51] pointed out that clients can reduce procurement risks by carrying out proper due diligence and reviewing procurement processes to ensure transparency, compliance, and contractor reliability. Jeong et al. [52] proposed a data-based approach to help clients set realistic contract timelines and manage scheduling risks more effectively.

2.3.2. Contractor-Related Strategies

Moore [53] outlined various risks contractors face, including operational, compliance, reputational, and financial risks, and suggested mitigation strategies such as thorough risk assessments, clear communication, performance monitoring, and strategic diversification. Similarly, Iqbal et al. [48] highlighted that contractors are also responsible for managing risks during the implementation phase, particularly those related to subcontractors, labour, machinery, material availability, and quality control. In line with this, Zerihun et al. [54] stressed the importance of improving relationships between contractors and subcontractors through enhanced communication, timely payments, trust-building, clear contractual agreements, and collaborative project management to optimise project performance.

2.3.3. Consultant-Related Strategies

Ferrall and Giffin [55] suggested fostering clear communication, defining roles, and promoting collaborative problem-solving between consultants and contractors as key strategies to improve project efficiency, minimise disputes, and ensure successful execution. Additionally, selecting the appropriate type of construction consultant based on project requirements, ensuring clear role definitions, effective collaboration, and specialised expertise is crucial to optimising project efficiency and success [56]. To further enhance project outcomes, Flevy [57] recommends improving internal consulting strategies within engineering firms by streamlining project management processes, adopting agile methodologies, leveraging digital technologies, and implementing continuous improvement practices to increase operational efficiency and ensure successful project delivery.

2.3.4. General Strategies

Construction leaders can mitigate risks by implementing five key strategies: establishing best practices around profitable projects, leveraging strong relationships, consulting experts on contracts, monitoring global events, and applying strategic decision-making to enhance resilience [58]. Mac-Barango [59] also suggests strategies for bidding to ensure the success of construction tenders by prioritising the awarding of contracts to the most qualified contractors, focusing on important factors such as contractor qualifications, financial stability, capacity, and past performance in the evaluation process. Du Plessis and Oosthuizen [60] however recommended enhancing construction project management by

aligning building contracts with project life cycle stages, improving contract clarity, and integrating structured management practices to optimise efficiency and project delivery.

Xia et al. [61] proposed that effective stakeholder management, with appropriate strategies and attributes, plays a significant role in improving project management and risk management performance. Jahan [62] added that understanding the needs, constraints, interests, objectives, expectations, and influences of all stakeholders involved in a project is essential for ensuring project success. Mwangi and Ngugi [63] emphasised that proper project design, adherence to legal and policy requirements, and thorough planning to ensure resource availability can help reduce risks when all stakeholders are actively involved in the planning process. Kristensen [64] highlighted the importance of communication and trust-building in fostering successful negotiations and collaborative relationships among stakeholders, which can prevent disputes and claims. Noting these strategies, Nahid et al. [65] stated that cultivating a strong, risk-aware culture, encouraging transparent communication, and promoting accountability and leadership are key strategies for early risk identification and mitigation.

2.4. Stakeholder Theory

Stakeholder theory has emerged as an important subject within the realm of business ethics and the nexus between corporations and society [66]. The existing understanding of stakeholder theory in civil infrastructure projects encounters various obstacles, such as the lack of a logical framework for justification, complexities in stakeholder management, overlooking stakeholders, and challenges in accurately identifying stakeholders [67]. Prior research has neglected to acknowledge the dynamic nature of stakeholder relationships, the heterogeneity of construction organisations, and the underlying causes of these transformations. Particularly neglected are the negative and contradictory associations that exist between construction organisations and their stakeholders [68]. Stakeholder theory thus emphasises that organizations, including, among others, construction organisations, must account for the varying interests of different stakeholders such as clients, contractors, and consultants [69] to succeed and mitigate risks, especially in complex environments like civil infrastructure projects [70].

This study therefore considered the adoption of stakeholder theory as it offers insight into the varying interests, power dynamics, and interactions among stakeholders that are crucial for the determination of the root causes of contractual claims risks as well as the mitigating strategies. Construction projects with strong stakeholder management frameworks tend to achieve better outcomes [71]. Thus, this study considers stakeholder theory as the most relevant theory to support the conceptual framework outlined in Section 2.5 and illustrated in Figure 1.

2.5. Conceptual Framework

The conceptual framework presented in Figure 1 indicates the latent and measurement variables that were examined. The framework indicates three latent variables, namely: factors causing contractual claims risk in civil infrastructure projects; the impact of such risks occurring; and essential strategies to mitigate the risks. The latent variables cannot be measured directly and are thus allocated measured variables identified through the literature review [72]. The measured variables related to the latent variables are:

- Measured Variable 1: client-related causes, contractor-related causes, consultant-related causes, external causes, finance-related causes, and contractual risk factors;
- Measured Variable 2: risk occurrence, risk effects on project delivery, risk associated with risk-causative variables, and frequency occurrence of contractual claims;

- Measured Variable 3: client strategies, main contractor's strategies, consultant's strategies, and general mitigation strategies.

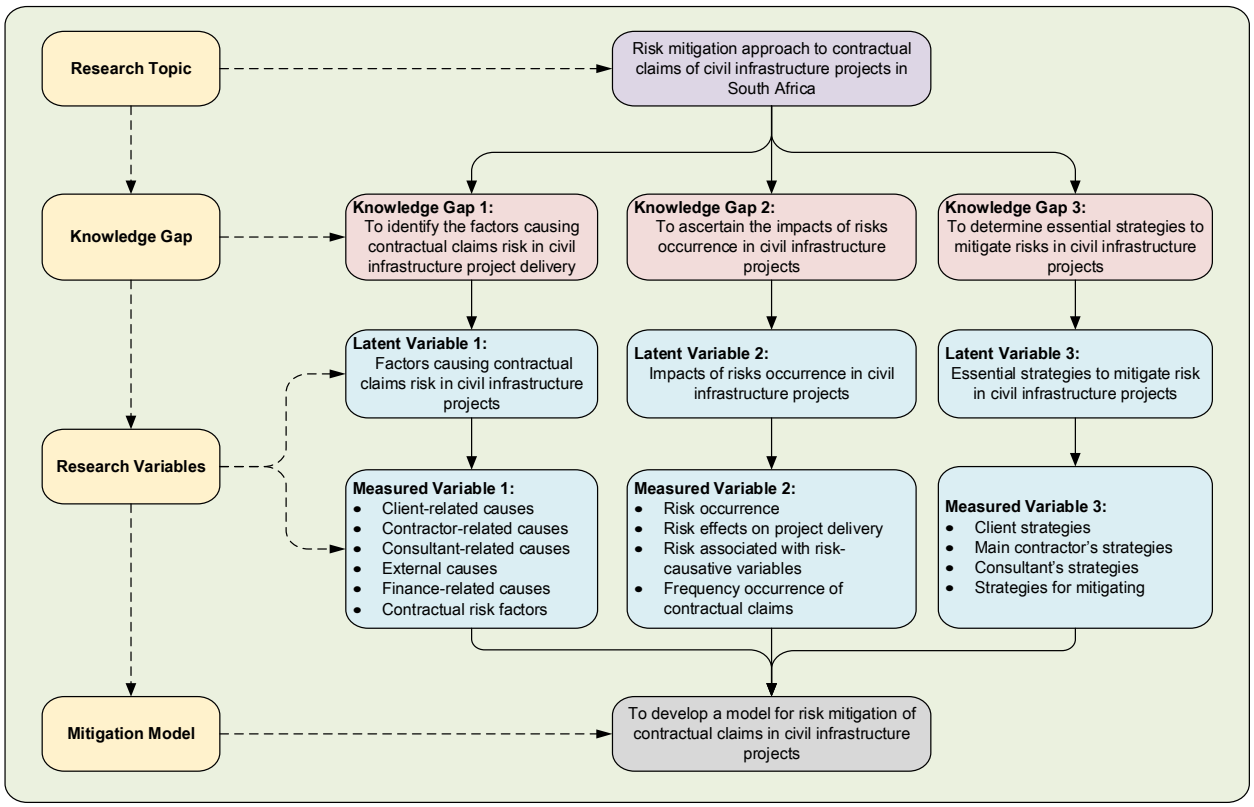


Figure 1. Conceptual framework (source: [73]).

Taking into consideration the knowledge gaps and variables highlighted in the conceptual framework, including the theory adopted by the study, the research aimed to develop a risk mitigation model to guide the appropriate mitigation of contractual claims risk in civil infrastructure projects in South Africa. With the latent and measured variables already identified, Table 1 indicates the predicted hypothetical relationships between the underlying variables with supporting literature, while the anticipated model represented by Figure 2 graphically illustrates the hypothetical relationships between the underlying variables.

Table 1. Predicted hypothetical relationships between underlying variables (source: [73]).

Hypotheses	Relationships	Supporting Literature
Hypothesis 1	A significant relationship exists between factors causing contractual claims risk in civil infrastructure project delivery and impacts of risk occurrence in civil infrastructure projects	[74–77]
Hypothesis 2	A significant relationship exists between the impacts of risk occurrence in civil infrastructure project delivery and essential strategies to mitigate risk in civil infrastructure projects	[78–83]
Hypothesis 3	There is a significant relationship between factors causing contractual claims risk in civil infrastructure project delivery and essential strategies to mitigate risk in civil infrastructure projects	[84–89]

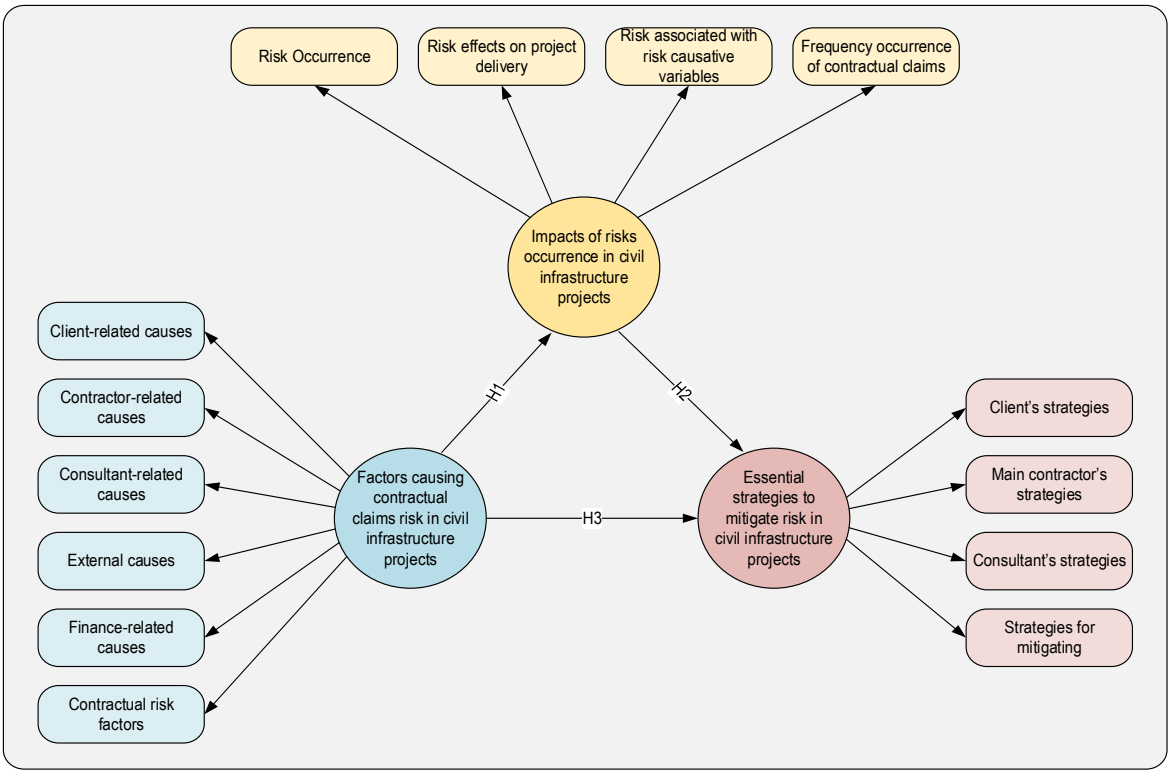


Figure 2. Anticipated model (source: [73]).

3. Methods

An explanatory sequential mixed method design was adopted which allowed for descriptive and inferential data collection and analyses [90,91]. The justification for selecting the explanatory sequential mixed method design stems from the need for a large set of quantitative data in phase 1 and a smaller set of qualitative data in phase 2 [92,93]. The small amount of qualitative data collected in phase 2 was used to put together appropriate case studies to supplement the quantitative data and to develop an effective risk mitigation model.

The questionnaire survey had seven sections, and the structured interview had five. The first and second sections of the questionnaire survey required respondents to answer questions related to demographic information, with the remaining sections requiring respondents to rate statements that identify the factors that cause contractual claims; ascertain the impact of risks occurring in civil infrastructure projects; and identify risk mitigation strategies, using a 5-point Likert scale.

The structured interviews also required respondents to answer general demographic questions. The following sections required respondents to answer open-ended questions regarding the factors responsible for the cause of contractual claims risk that influences performance in civil infrastructure projects; what impact these risks have on the project delivery; their opinions on the significance of contractual risk in project delivery; whether stakeholders' interests were considered during the implementation of projects; and what type of risk mitigation model they would recommended to manage contractual claims risks in civil infrastructure projects.

In this study, descriptive data analysis was used to identify the factors that cause contractual claims, ascertain the impact of risks occurring in civil infrastructure projects, and identify risk mitigation strategies for managers in the South African civil construction industry. A thematic analysis was used to determine three themes from the interview data [94]. The combined results were used to determine the latent variables and measur-

able variables to be included in the risk measurement model, as indicated in Section 2.4. Inferential statistics (PLS-SEM) were used to analyse whether significant relationships exist among these latent and measurable variables associated with the structural constructs, as well as to establish if the model is suitable to measure risk.

3.1. Sample and Data Collection (Questionnaire Survey—Phase 1)

For the first phase of data collection, the selection of research participants was achieved using a stratified random sampling approach from a set of diverse professionals involved in project direction (13), project management (71), supervision (49), consulting (9), and contracting (24) [95–97]. The participants were selected from the construction firms registered on the Construction Industry Development Boards (CIDB) under the General Building (GB) and Civil Engineering (CE) classes of work, from grade 3 to 9, with experience in contractual claims risk in civil infrastructure projects in South Africa. This sampling approach aided the selection of participants to eliminate selection bias and to ensure that the sample was representative of the larger population [98].

To determine the sample size for phase one, a suitable representative sample of 50% was assumed for this study [99,100], at a 95% confidence level, with a significance level of $\alpha = 0.05$: z = 1.96 at 95% confidence level, and a confidence interval of c = ±10%. The sample size was calculated using Equation (1) [101,102]:

$$\text{ss} = \text{z}^2 \times \frac{p\,(1\ -p)}{\text{C}^2} \tag{1}$$

where

ss = sample size;
z = standardised variable;
p = percentage picking a choice, expressed as a decimal;
C = confidence interval, expressed as a decimal.

The sample size was calculated as follows:

$$ss = \ 1.96^2 \times \frac{0.5\ (1\ -\ 0.5)}{0.1^2} = 0.9604 = 96.04$$

Based on the above, it is important to consider non-responses in the sample size by assuming a 25% response rate within a 20–30% response range for the calculation of the appropriate survey sample size [103–105]. Therefore, the survey sample size was calculated as follows:

$$\text{Survey } ss = \frac{\text{new ss}}{\text{response rate}} \tag{2}$$

$$\text{Survey } ss = \frac{96}{0.25} = 384 \tag{3}$$

The survey sample size for the first phase of the data collection process was therefore 384 respondents, who were randomly selected, as proposed by Morton et al. [105]. Of the 384 survey questionnaires administered electronically to the research sample via SurveyMonkey and email, only 166 were appropriately completed and retrieved, giving a response rate of 43% [105,106]. The use of an online survey tool such as SurveyMonkey for quantitative data collection involving a large population is supported by [107,108]. Table 2 presents the distribution of questionnaires and responses received across the nine provinces in South Africa.

Table 2. Questionnaire distribution vs. responses (source: [73]).

Province	Distributed	Received	Percentage (%)
Western Cape	90	60	66.7
Gauteng	76	32	42.1
Northern Cape	30	12	40.0
Northwest	40	7	17.5
KwaZulu-Natal	60	21	35.0
Eastern Cape	10	8	80.0
Mpumalanga	30	14	46.7
Limpopo	18	10	55.6
Free State	30	2	6.7
Total	384	166	43.2

3.2. Sample and Data Collection (Structured Interview—Phase 2)

For the second phase of data collection, a purposive sampling approach was adopted to aid the selection of participants for the qualitative structured face-to-face interviews [92,93,98,108]. A formal letter was emailed to the construction organisations as a precautionary measure to ensure fairness in the selection of the participants for the qualitative structured interview. The letter requested the consent of the selected participants who had taken part in the structured questionnaire survey. From the 166 responses collected in the quantitative survey, seven respondents consented to be interviewed. Many scholars emphasize that saturation is the most crucial factor in determining the sample size for qualitative research, as highlighted by Mason [109]. In line with the justification for adopting an explanatory mixed-method design, the research achieved saturation after seven interviews [110].

The structured interviews incorporated open-ended questions in face-to-face sessions to elicit more detailed responses on: the factors causing contractual claims risk in project delivery; the impacts of risks on stakeholders during projects; the risk mitigation strategies used; and perceptions on determining the appropriate operational model for risk mitigation. Individual interviews were conducted with seven construction professionals from different construction companies based on their level of experience as stakeholders in the execution of civil projects in South Africa. Approval was obtained from all interviewees to use an audio recorder. The discussions were documented and transcribed into useable qualitative data. Interview guidelines were read to the interviewees to ensure standardised procedures across sessions [107,111].

3.3. Method of Data Analysis

The analysis of the data was conducted in three parts. The first dataset indicated demographic information related to the research participants. This was followed by the extraction of the measurement and latent variables (Appendix A), which were collated utilising the analysed data from the questionnaire survey and structured face-to-face interviews. The measurement and structural models were analysed thereafter. The analysis of the measurement model using partial least squares structural equation modelling (PLS-SEM) began with identifying potential structural relationships among latent variables associated with the structural constructs. The PLS-SEM analysis was processed using SmartPLS4 (version 4.1.0.0) to derive standardised regression weights, factor loadings, and percentage of variance explained by the explanatory variables. This analysis shows some degree of correlation between the reflective indicators of the latent variables. This study considered 0.5 as the standard for individual item reliability (factor loadings), which is deemed acceptable according to Civelek [112] and Hair et al. [113]. Other criteria like composite reliability (CR) and average variance extracted (AVE) were used to observe

and deduce the results of the path model [114,115]. The coefficients of determination (R^2) and path coefficients (β) (for hypothesis testing: *t*-values and *p*-values) were calculated to determine how each latent construct contributes to the predictive capability of the endogenous constructs.

The PLS algorithm of the structural model was used to analyse and investigate relationships between variables and to establish model fit [113,116,117]. This entailed running the PLS algorithm to determine the variance explained by the model's variables and the significance levels of the paths that led to the PLS estimates. As suggested by [113,118], R^2 was used to assess the overall predictive capacity of the structural model. The bootstrapping technique was applied with 500 samples to determine the significance level of the variables, resulting in the structural model with β and *t*-statistics. For bootstrapping, a *t*-statistic greater than 1.65 indicates significance at $p \leq 0.10$. A *t*-statistics greater than 1.96 indicates significance at $p \leq 0.05$, while a value above 2.57 indicates significance at $p \leq 0.01$ [119–123]. In addition, a global goodness-of-fit (GoF) index was used, which represents the minimum benchmark for the global validation of the PLS path model [124–126].

4. Results and Discussion

4.1. Demographic Profile of the Respondents

Table 3 presents the demographic information of the respondents. One hundred and sixty-six (166) respondents operated in one of five operational positions: project director, project manager, supervisor, consultant, or contractor. The data demonstrate that 42.8% (71) of the respondents worked as project managers, 29.5% (49) as supervisors, and 14.5% (24) as contractors, while only 13.2% of the respondents were project directors and consultants. In addition, information on respondents' years of work was collected to validate their relevance to this study. The data indicate that over 90% of the respondents had more than 5 years of working experience, with less than 10% having worked for less than 5 years.

Table 3. Demographic information (source: [73]).

Factors	Variables	Frequency (n = 166)	%
Position in organisation	Project Directors	13	7.8
	Project Managers	71	42.8
	Supervisors	49	29.5
	Consultants	9	5.4
	Contractors	24	14.5
Years of work	0–5 years	12	7.2
	6–10 years	40	24.1
	11–15 years	35	21.1
	16–20 years	40	24.1
	Above 20 years	39	23.5
Projects executed	Building	47	28.3
	Roads and Bridges	58	34.9
	Rail Lines and Infrastructure	27	16.3
	Water Engineering and Sewage Disposal Lines	34	20.5
Organisation size (CIDB Grade)	Grade 3	17	10.2
	Grade 4	35	21
	Grade 5	36	21.7
	Grade 6	38	22.9
	Grade 7	13	7.8
	Grade 8	12	7.2
	Grade 9	15	9

Table 3. *Cont.*

Factors	Variables	Frequency (n = 166)	%
Client types	Public Sector	56	33.7
	Private Sector	110	66.3
Operational areas	Eastern Cape	4	2.4
	Free State	7	4.2
	Gauteng	60	36.1
	KwaZulu-Natal	18	10.8
	Limpopo	7	4.2
	Mpumalanga	1	0.6
	Northern Cape	3	1.8
	Northwest Cape	2	1.2
	Western Cape	64	38.6

4.2. Measurement Model Results

The structural model (Figure 3) shows that all selected variables exceeded the 0.5 threshold for factor loadings [127], demonstrating that all variables should be retained in the model rather than deleted [128]. The evaluation of the reliability of individual items on the latent variables, as shown in Table 4, reveals robustness in internal reliability, as demonstrated by the composite reliability. This indicates that the items measure distinct or the same concepts of establishing potential model performance rates [110,129,130].

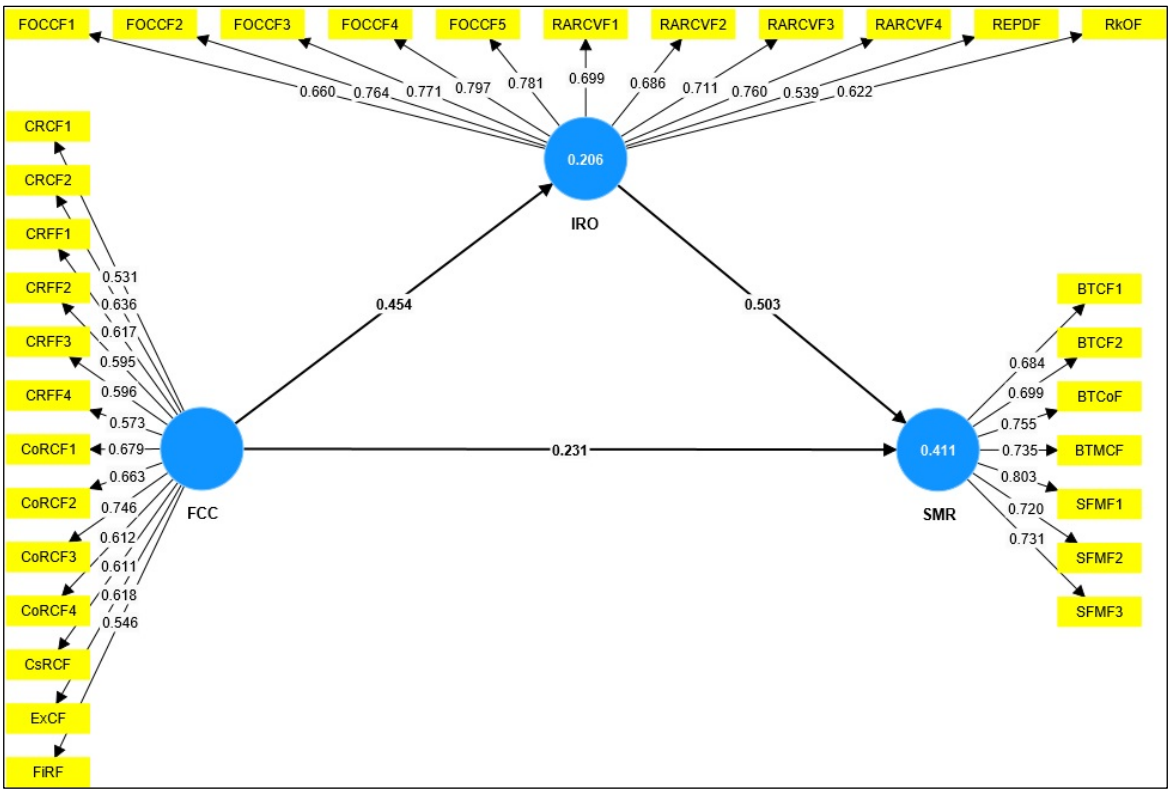


Figure 3. Structural model with path coefficients (β) and coefficients of determination (R^2) values (source: [73]).

Table 4. Latent variables inter-construct correlation and reliability measures (source: [73]).

Latent Variables	AVE	CR	R Square	CA	FCC	IRO	SMR 3
Factors causing contractual claims risk in civil infrastructure project delivery (FCC)	0.384	0.889		0.876	1		
Impacts of risks occurrence in civil infrastructure projects (IRO)	0.507	0.917	0.206	0.903	0.454	1	
Essential strategies to mitigate risk in civil infrastructure projects (SMR)	0.538	0.861	0.411	0.857	0.459	0.607	1

These findings, which are in line with Fornell and Larcker [131], confirm that the convergence validity of the constructs is adequate. The evaluation of the matrix diagonals, specifying the square roots of the average variance extracted (AVE), revealed values greater than the off-diagonal elements in their respective rows and columns, strengthening the discriminant validity of the scales used. The results in Figure 3 show higher factor loadings, which imply that the constructs and indicators have a satisfactory shared variance [121,122]. Considering these findings, the model demonstrates acceptable reliability and validity in explaining the relationships between its constituent constructs.

4.3. Validation of the Structural Model Results

Convergent validity was tested and confirmed by linking the latent variables of the model to obtain factors and cross-loadings for all indicator items and their corresponding latent variables, as suggested by Wentzel et al. [119]. The structural model with path coefficients, as indicated in Figure 3, shows that all items loaded on their individual latent variables between 0.531 and 0.803. When investigating interaction effects within the proposed structural model, the PLS algorithm was used to determine relationships between variables. According to Wentzel et al. [119], this approach sought to establish the variance explained by the variables in the model, as well as to determine the significance levels of the paths leading to the PLS estimates. Path coefficients were calculated to determine the relative contributions of each latent explanatory construct to the endogenous construct's predictive capacity. Figure 3 shows that the exogenous and endogenous constructs of the model contribute positively to one another. The overall predictive capacity of the structural model was assessed using the R^2 value associated with the model's endogenous constructs, which exceeded 10%, an acceptable threshold according to [110,132].

To determine the significance level of the variables, the bootstrapping technique in SmartPLS4 was run using 500 resamples to produce Figure 4, which illustrates the structural model with path coefficients and *t*-statistics.

4.4. Structural Equations to Validate the Structural Model

The structural model displayed in Figures 3 and 4 shows how the latent variables relate to one another. The latent variables in SEM are categorised as endogenous and exogenous variables. The endogenous variables are influenced by other variables in the path model, as indicated by the regression path [133,134]. In contrast, the exogenous variables are unaffected by other variables in the path model, as indicated by regression path arrows exiting them [133,134]. In other words, endogenous variables exhibit dependency, while exogenous exhibit independence. Based on the illustration in the structural model (Figures 3 and 4), factors causing contractual claims risk in civil infrastructure project delivery are observed as exogenous variables, which signifies that they are not influenced by

other variables in the model. In contrast, the impacts of risk occurrence in civil infrastructure projects and essential risk mitigation strategies are observed as endogenous variables, which signifies that they are influenced by other variables in the model. The path model, which is based on the principles of linear regression combinations [130], demonstrates latent causal dependencies between endogenous and exogenous variables. The path linkages established in the model aided in the basic configuration of the PLS-SEM path Equations (4) to (6), showing the linear hypothetical relationship between these latent constructs. These path equations depict the causal dependencies between the latent constructs, including the hypothetical interpretation of the predictive strength of the model. The equations for the structural model are as follows:

$$\textit{Factors causing contractual claims risk in civil infrastructure project delivery } (FCC) = FCC{+}0(\textit{exogenous variable}) \quad (4)$$

$$\begin{aligned} &\textit{Impacts of risks occurrence in civil infrastructure projects } (IRO) = \beta_1 \\ &\bullet\ \textit{Factors causing contractual claims risk in civil infrastructure project delivery } (FCC) + \varepsilon_1 \end{aligned} \quad (5)$$

$$\begin{aligned} &\textit{Essential risk mitigation strategies in civil infrastructure projects } (SMR) = \\ &\beta_2 \bullet \textit{Impacts of risks occurrence in civil infrastructure projects } (IRO) + \\ &\beta_3 \bullet \textit{Factors causing contractual claims risk in civil infrastructure project delivery } (FCC) + \varepsilon_2 \end{aligned} \quad (6)$$

where

β_1 denotes the path coefficient between FCC and IRO;
β_2 denotes the path coefficient between IRO and SMR;
β_3 denotes the path coefficient between FCC and SMR;
ε_1 represents the error term (*unexplained variance in IRO by FCC with the ability to predict*);
ε_2 represents the error term (*unexplained variance in SMR by IRO and FCC with the ability to predict*).

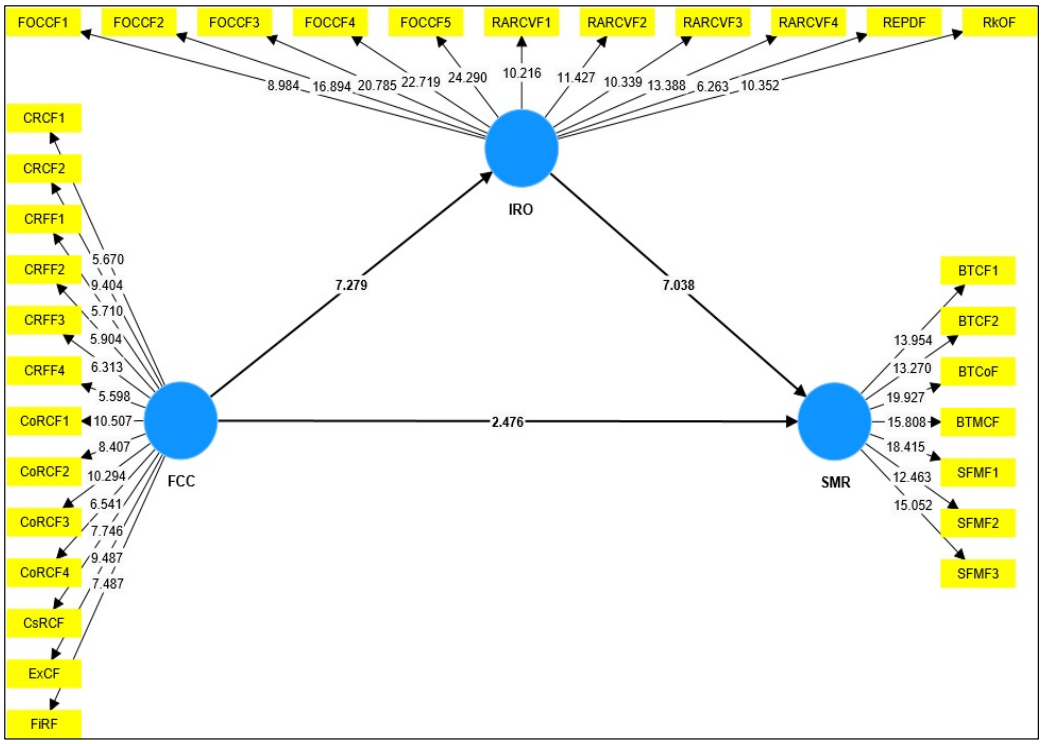


Figure 4. Structural model with hypothesis test statistics (*t*-statistics) (source: [73]).

Figure 5 depicts the PLS-SEM path equations explaining the causal dependence between the three latent constructs. The causality diagram simplifies the linear regression

paths linking the three latent constructs by denoting the path effect directions (path coefficients) between them as follows:

- Pxy: factors causing contractual claims risk in civil infrastructure project delivery → impacts of risks occurrence in civil infrastructure projects;
- Pyz: impacts of risks occurrence in civil infrastructure projects → essential strategies to mitigate risk in civil infrastructure projects;
- Pxz: factors causing contractual claims risk in civil infrastructure project delivery → essential strategies to mitigate risk in civil infrastructure projects.

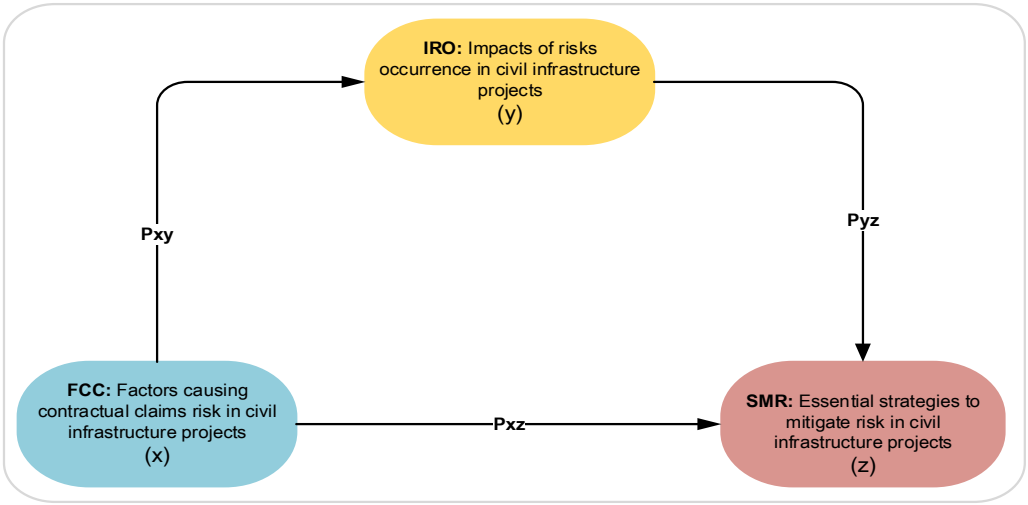


Figure 5. Diagram of causal dependence between the latent variables (source: [73]).

Figure 6 illustrates the risk mitigation model to address contractual claims risk in civil infrastructure projects in South Africa. The model constructs and measurement variables for each construct are shown in the model.

4.5. Model Evaluation

The assessment of the PLS model's performance and capacity to generate significant predictions was conducted via measurement and structural models, which served as the basis for the overall evaluation of the model [122]. To estimate the performance of the PLS model, its fitness was determined by calculating its goodness of fit (GoF), a metric used to evaluate the predictive capability and overall performance of a model [135,136]. GoF is defined as the geometric mean of the average variance extracted (AVE) and the average of the R^2 values for all endogenous latent variables [135–137].

A GoF value of 0.38 was calculated by finding the square root of the average of both R^2 and AVE values presented in Table 4. Based on the threshold categories, this value falls within the 'Good fit' threshold of GoF > 0.36, as shown in Table 5. This confirms that the partial least squares (PLS) model is effective in explaining the relationships between the causes, impact, and strategies developed for the risk mitigation of contractual claims in civil infrastructure projects in South Africa.

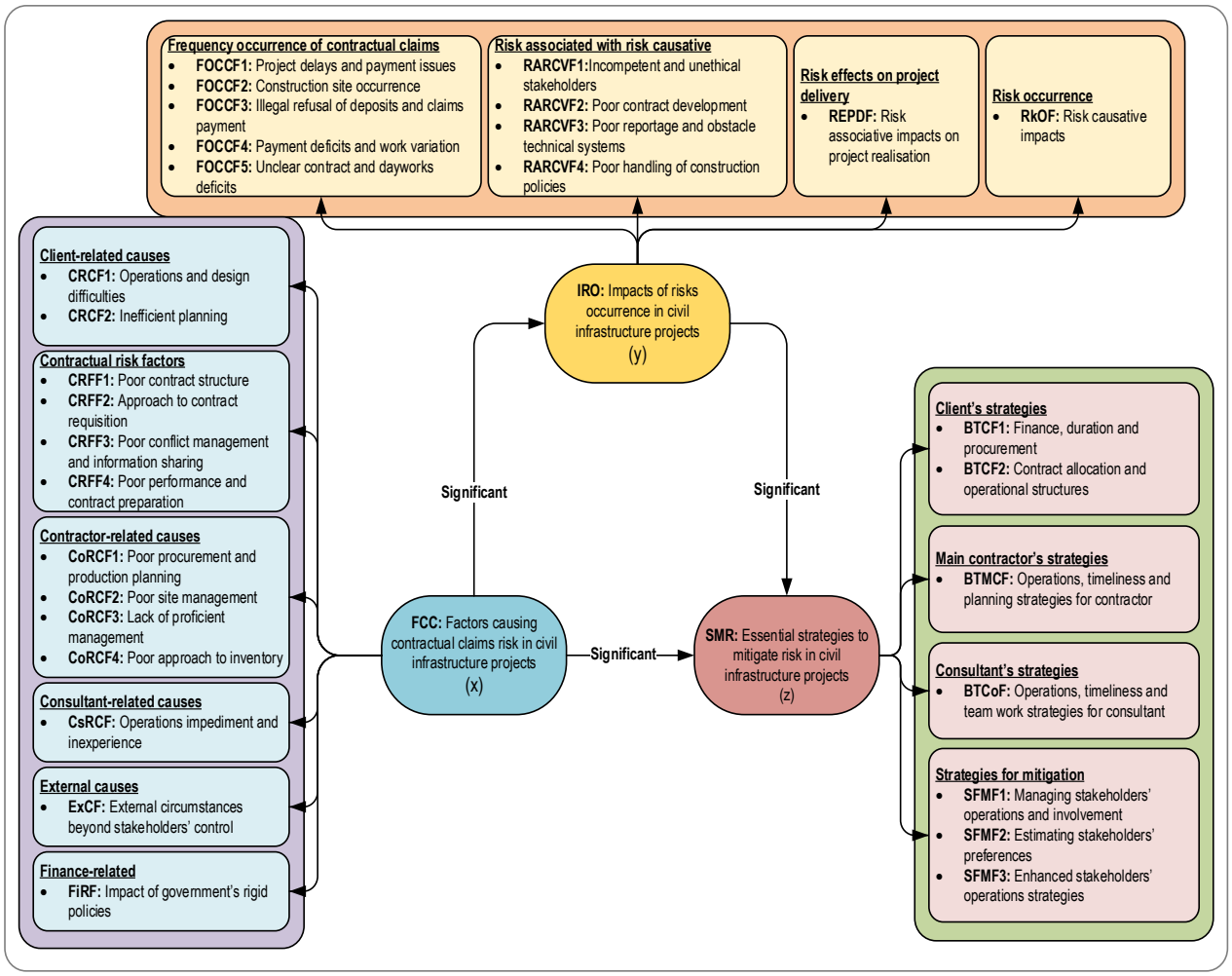


Figure 6. Risk mitigation model to govern contractual claims risk occurrence in civil infrastructure projects in South Africa. (source: [73]).

Table 5. Goodness-of-fitness threshold (source: [73,133,138–140]).

Goodness-of-Fit (GoF) Value	Goodness-of-Fit (GoF) Index
GoF greater than 0.36	Good fit
GoF between 0.25 to 0.36	Medium fit
GoF between 0.1 to 0.25	Poor fit
GoF less than 0.1	No fit

5. Discussion of Findings from the Model Results

The PLS model results indicate that factors causing contractual claims risk in civil infrastructure project delivery (FCC) have a direct effect on the impacts of risks occurrence in civil infrastructure projects (IRO). FCC explained 45.4% (a large proportion) of variance in IRO (Figure 3—path coefficients), which signifies the strong influence of the exogenous latent construct (FCC) as a strong predictor of IRO. This is strengthened by a predictive ability of 20.6% (R^2 = 0.206) pertaining to the contribution threshold of FCC to IRO (refer to Figure 3). In other words, factors encouraging contractual claims risk are responsible for more than 20.0% of the variation in the impact of the risks on civil infrastructure project delivery in South Africa.

These impacts are consolidated by the significant contribution of reflective indicators in FCC, such as operational and design difficulties, inefficient planning, poor procurement and production planning, poor site management, poor approach to inventory, operational

impediments and inexperience, external circumstances beyond stakeholders' control, including the impact of rigid government policies, poor contract structure, approach to contract requisition, poor conflict management and information sharing, and poor performance and contract preparation. Based on the contributions of the reflective indicators to the predictive power of FCC, the relationship between FCC and IRO is statistically significant at $t = 7.279$; $p < 0.05$, as illustrated in Figure 4—hypothesis test statistics.

To strengthen the above, Hiyassat et al. [78], in a study conducted on risk allocation in public construction projects in Jordan, identified related factors such as poorly tailored contract forms, change in design, and poor design as significant risks influencing construction projects. The same study further cited inefficient planning, government corruption, and poor performance and management as other significant risks influencing construction projects [74,78]. In addition, Kassem [138] provided a clear overview of the cause-and-effect relationships in construction project risks, showing how these resulted in conflict, cost, and time overruns, thus supporting the hypothetical relationship between FCC and IRO. This is also supported by the findings reported by Arditi and Pulket [141].

The model results also show that FCC and IRO have a direct effect on SMR. FCC explained 23.1% (a medium proportion) of the variance in SMR, alongside 50.3% (a large proportion) of the variance explained by IRO in the endogenous variable (Figure 3—path coefficients). This signifies that IRO (an exogenous latent construct) is highly significant in predicting SMR, contributing more to the explained variance than FCC (exogenous latent construct). The above is supported by evidence that both FCC and IRO have a predictive power of 41.1% ($R^2 = 0.411$) in relation to their contribution to SMR, as shown in Figure 4. This implies that factors causing contractual claims risk and their impact on civil infrastructure project delivery in South Africa account for more than 40% of the variation in essential strategies to mitigate risk in civil infrastructure projects.

Concerning the practical significance of IRO in the model, the findings indicate that reflective indicators, such as risk-associated impacts on project realisation; incompetent and unethical stakeholders; poor contract development; inadequate reporting and obsolete technical systems; poor handling of construction policies; project delays and payment issues; construction site occurrences, unjustified refusal of deposits and claims payments; payment deficits and work variation; and unclear contract and daywork provisions, all significantly contribute to the predictive power of IRO. This is supported by the findings reported by [142,143]. The relationship between IRO and SMR is statistically significant at $t = 7.038$; $p < 0.05$, as illustrated in Table 5—hypothesis test statistics.

With regard to the potential causal relationships between the latent constructs and their respective indicators, it is observed that the impact of FCC on SMR is significantly influenced by reflective indicators related to finance, duration and procurement, contract allocation and operational structures, operations, timeliness, teamwork strategies for consultants, management of stakeholder operations and involvement, estimation of stakeholder preferences, and enhancement of stakeholder operation strategies. The relationship between FCC and SMR is statistically significant at $t = 2.476$; $p < 0.05$, as illustrated in Table 5—hypothesis test statistics. This finding is supported by a study conducted by [144].

The PLS model shows that factors causing contractual claims risk in civil infrastructure project delivery have significant relationships and strong predictive capacity to influence both the impact of risk occurrence in civil infrastructure projects and essential strategies to mitigate these risks. The overall predictive strength of the risk mitigation model is acceptable, as the R^2 values are well above 10%, with the PLS-SEM results indicating over 60% predictive ability by the exogenous latent constructs. The established predictive strength of the risk mitigation model thus confirms its adequacy in explaining the relationships among the three constructs. Based on this, the model validates the study's hypotheses: that

significant relationships exist between the three constructs, from FCC to IRO, FCC to SMR, and IRO to SMR, as illustrated in Table 6.

Table 6. Effects of the structural model results on the predicted links in the PLS-SEM path model (source: [73]).

Path Label	Path Relationship	*t*-Statistic	Corresponding Hypothesised Path	Observation on Hypothesis
Pxy	FCC (factors causing contractual claims risk in civil infrastructure project delivery) → IRO (impacts of risks occurrence in civil infrastructure projects)	Significant	Hypothesis 1 (H1): A significant affiliation exists between factors causing contractual claims risk in civil infrastructure project delivery and impacts of risk occurrence in civil infrastructure projects	Supported
Pyz	IRO (impacts of risks occurrence in civil infrastructure projects) → SMR (essential strategies to mitigate risk in civil infrastructure projects)	Significant	Hypothesis 2 (H2): A significant association exists between essential strategies to mitigate risk in civil infrastructure projects and impacts of risk occurrence in civil infrastructure projects	Supported
Pxz	FCC (factors causing contractual claims risk in civil infrastructure project delivery) → SMR (essential strategies to mitigate risk in civil infrastructure projects)	Significant	Hypothesis 3 (H3): There is a significant relationship between essential strategies to mitigate risk in civil infrastructure projects and factors causing contractual claims risk in civil infrastructure project delivery	Supported

6. Conclusions

From the literature reviewed, it was observed that several risk management methods and procedures developed by the construction industry to enhance project performance are inadequate for mitigating claims risk in civil infrastructure [145,146]. This issue is further compounded by the lack of consensus among researchers and construction industry practitioners in South Africa regarding key factors and practices in risk assessment, as well as the selection of appropriate techniques for developing a risk management model that effectively mitigates risks and enhances civil infrastructure project performance metrics [21]. This study established how contractual claims risk is perceived by the construction industry, and that risk management procedures for adequate project performance are either not well understood or not properly applied to evaluate risk occurrence during construction projects.

A major contribution of this study was the development of a model for the effective risk mitigation of contractual claims risk in civil infrastructure projects in South Africa, including its practical application in various areas where such risks hinder project delivery within stipulated timeframes and budgets. The model was validated through hypothesis testing. The suitability of PLS-SEM was supported by [147,148], who state that PLS-SEM is a strong multivariate technique for research that aims to improve theories in management research because it offers various usage advantages. Limited application of this technique in construction management research has been observed, particularly in comprehensive studies on risk management [148]. However, this study demonstrates the multivariate potential of the PLS-SEM approach in analysing risk management by

modelling relationships of variables in construction management. The model shows that factors causing contractual claims risk during the delivery of civil infrastructure projects influence both the impacts of risk occurrence and essential strategies needed to mitigate such risks. Hence, the model can be used to support the following:

- Providing solutions based on the significant relationships that exist among the causes, impacts, and mitigation strategies related to contractual claims risk in civil infrastructure projects in South Africa;
- Promoting risk mitigation mechanisms that support cost control, performance improvement, and attainable delivery schedules in civil infrastructure projects, based on appropriate identification and estimation of the association between the causes and impacts of contractual claims risk;
- Promoting operational techniques that enhance the effectiveness of mitigation strategies in improving financial management, contract administration, work allocation, operational structures, and conflict reduction.

Based on the reviewed literature, this is the first time that a risk mitigation model of this nature has been developed specifically to reduce claims in civil infrastructure projects in South Africa. Although data collection was restricted to South Africa, it is important to highlight that the basic approach, data analysis techniques, and the model itself can be adapted for use in other countries.

The research was conducted with some limitations, primarily related to the use of questionnaires for data collection. The questionnaires were administered to construction professionals in South Africa, employed by firms registered with the CIDB between grades 3 and 9. It was also difficult to schedule interviews with the selected construction professionals, as many prioritised their work commitments over research participation.

Investigations into the development of effective risk mitigation models are gradually becoming a focal point in construction management, particularly in the South African construction industry. Based on the findings and limitations of this study, the following are proposed as areas of research that could be explored in the future:

- The role that technology can play in minimising project losses through the development of a project cost, time, and performance framework to stabilise project delivery processes in South Africa;
- Developing an interactive framework to enhance collaboration among project stakeholders and teams, thereby promoting efficient project performance across various departments in general building and civil engineering, such as construction design, production, risk management, project management, and quantity surveying;
- The reliability of the constructs and key indicators incorporated in the risk mitigation model developed in this study could be investigated by exploring these constructs and their associated variables.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Engineering and the Built Environment Ethics Committee of the Cape Peninsula University of Technology (23 March 2021).

Data Availability Statement: Restrictions apply to the datasets. The thesis and dataset have not yet been uploaded to the university library repository. This will be done in the next few months.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Theoretical model of latent variables extracted (source: [73]).

Latent Variable Constructs	Measurement Variables
Factors causing contractual claims risk in civil infrastructure project delivery (FCC)	**Client-related causes** Operations and design difficulties (CRCF1) Inefficient planning (CRCF2) **Contractor-related causes** Poor procurement and production planning (CoRCF1) Poor site management (CoRCF2) Lack of proficient management (CoRCF3) Poor approach to inventory (CoRCF4) **Consultant-related causes** Operational impediments and inexperience (CsRCF) **External causes** External circumstances beyond stakeholders' control (ExCF) **Finance-related** Impact of rigid government policies (FiRF) **Contractual risk factors** Poor contract structure (CRFF1) Approach to contract requisition (CRFF2) Poor conflict management and information sharing (CRFF3) Poor performance and contract preparation (CRFF4)
Impacts of risks occurrence in civil infrastructure projects (IRO)	**Risk occurrence** Risk-causative impacts (RkOF) **Risk effects on project delivery** Risk-associated impacts on project realisation (REPDF) **Risk associated with risk-causative variables** Incompetent and unethical stakeholders (RARCVF1) Poor contract development (RARCVF2) Poor reporting and obsolete technical systems (RARCVF3) **Frequency of contractual claims** Project delays and payment issues (FOCCF1) Construction site occurrences (FOCCF2) Unjustified refusal of deposits and claims payments (FOCCF3) Payment deficits and work variation (FOCCF4) Unclear contract and daywork provisions (FOCCF5)
Essential strategies to mitigate risk in civil infrastructure projects (SMR)	**Client strategies** Finance, duration, and procurement (BTCF1) Contract allocation and operational structures (BTCF2) **Main contractor strategies** Operations, timeliness, and planning strategies for contractors (BTMCF) **Consultant strategies** Operations, timeliness, and teamwork strategies for consultants (BTCoF) **Strategies for mitigation** Managing stakeholder operations and involvement (SFMF1) Estimating stakeholder preferences (SFMF2) Enhancing stakeholder operation strategies (SFMF3)

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