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EARLY VIEW

# **Improvement of Risk Management in Cost Estimation in the Building Construction Industry in Uganda**

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## **ABSTRACT**

The cost performance of construction projects is a crucial success factor. However, risks in construction projects make exact budgetary requirements challenging to forecast accurately, resulting in underestimation and overestimation. Inaccurate cost estimates have further resulted in unnecessary financial loss to the project stakeholders and loss of reputation and trustworthiness of construction professionals. In Uganda, risk factors are either ignored or subjectively taken care of by simply allowing a contingency figure ranging from 0% to 10% of the project cost. This method is sometimes unreliable and difficult to justify to the project owners. Therefore, there is a need for a risk-based cost estimation method that is reliable and justifiable. The study aimed to improve risk management in cost estimation in the building construction industry in Uganda. The specific objectives were; to establish the risk factors, assess the effects of the risk factors and develop a reliable model that can be used for risk-based cost estimation in the building construction industry in Uganda. The study adopted a mixed-method approach using quantitative and qualitative research methods. The collection of data was done by use of a self-administered questionnaire and an interview guide. The data was first sorted, coded and entered for analysis using the Statistical Package for the Social Sciences (SPSS) and Excel. The risk factors in cost estimation were identified through a detailed literature review. The study revealed that the top five risk factors were: cost of materials, inflation, fraudulent practices and kickbacks, incomplete scope definition and incomplete design and specification. The study concluded that the risk factors with the most severe effects on cost estimation were: inflation, proficiency in estimating, cost of materials, incomplete design and specification, fraudulent practices and kickbacks. The study proposes a model developed using the Analytic Hierarchy Process (AHP). The study recommended more research on the efficiency and effectiveness of risk-based cost estimation models.

**Keywords:** Risks, Risk management, Cost estimation, Risk-based cost estimation, Analytic Hierarchy Process (AHP).

### **INTRODUCTION**

The construction industry is one of the hugest sectors that contributes to the transformation of the economy of countries worldwide. The development of physical infrastructure can measure the pace of economic growth of a nation. In Uganda, the construction industry contributed 5.2% to the total gross domestic product (GDP) in 2020/2021 compared to 5.5% in 2019/2020 (UBOS, 2021). The construction industry is subjected to more risk and uncertainty than many other sectors causing projects to surpass their estimated budgets (Abdel-Monem, Alshaer and El-Dash, 2022). Uganda's construction industry is diverse and faces the challenges of cost and time overruns (CoST, 2017). Project cost and time overruns put the competence and integrity of construction professionals that plan and predict costs in doubt (Ajator, 2017). Despite all the knowledge and best practices in project management, most projects still do not meet their cost objectives (Herszon and Keraminiyage, 2014). This is evident in recent studies by many other researchers. In their research to investigate the influence of negotiation strategies on construction cost overruns, Kepher, Nyonje and Rambo (2022), stated that even with the engagement of construction professionals, cost overruns still provide a significant challenge in the construction industry. In another study aimed at finding the critical competency skills that project managers must

possess, Dlamini and Cumberlege (2021), indicated that one of the significant problems in the construction industry is cost overruns which negatively impact the contractual stakeholders. Referring to Xie *et al.* (2022), in a study aimed at developing a fuzzy model for evaluating the critical factors of cost overruns for construction projects, it was concluded that the construction industry has poor cost performance in finishing projects within budget. As described by Kamau, Gesimba and Gichuhi (2022), in a recent study sought to establish the influence of cost control on the realisation of government projects, available data shows that projects are riddled with cost overruns. Furthermore, a study aimed at assessing the critical factors affecting the performance of construction projects stated that cost overruns are one of the challenges construction projects face (Bahati and Kwena, 2023). To an average Ugandan, foul play or corruption is usually suspected given the size of cost overruns.

The inability to arrive at a reliable project cost estimate has resulted in project cost overruns and sometimes subsequent abandonment. Risk factors affecting cost estimation are either ignored or done subjectively by simply allowing for a contingency figure. Risks associated with cost estimation have not been managed effectively or accurately determined over time (Ojo and Odediran, 2015). Therefore, a model that incorporates risks in cost estimation may be beneficial in addressing this limitation in the building construction industry in Uganda.

### **LITERATURE REVIEW**

#### **Risk factors in construction**

Many definitions of risk exist in common usage. According to International Organization for Standardization (2009), risk is the effect of uncertainty on objectives. Project Management Institute (2013), defines risk as an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives. Risks in construction projects may be external, design, commercial, construction and operational factors that impact cost, time and quality in varying degrees (Ajator, 2017). Due to inherent risks, construction projects fail to complete within the agreed time and budget (Chileshe and Kikwasi, 2013). In Uganda, the construction industry faces various risks resulting in poor performance of projects with cost and time overruns (Umutoni, 2014). Kibwami (2020) also stated that in Uganda, the arbitrary and deterministic contingencies of 0% - 10% in building projects are routinely inadequate to contain up to 52% cost overruns.

A risk factor is a potential complication or problem which can affect project completion and the achievement of its objectives. It is an uncertain future event or condition with an occurrence rate greater than 0% but less than 100% that will affect at least one of the project objectives (Rezakhani, 2012). These risk factors must be evaluated during cost estimation to develop a more realistic project estimate. According to Umutoni (2014), the ten most significant risk factors in the

construction industry in Uganda are: financial failure, inflation, awarding the design to an unqualified designer, quality of work and time constraints, delayed payment on contract, lack of consistency between bills of quantities, drawings and specifications, change order negotiations, not coordinated design, changes in work and defining scope of work.

In a study aimed at identifying the risk factors affecting construction project performance, Tessema, Alene and Wolelaw (2022), concluded that the risk factors with the highest magnitude of impact were: inflation and price increases, flawed design, poor material quality, delayed payment to the contractor and subpar work while the risk factors with the most negligible magnitude of impact were: labour strikes, lack of a clear scope of work, delays in acquiring site access and lack of site access. They further stated that the most significant risk factors for building projects were: construction and design risk, poor management, insufficient funding, uncertain political conditions, lack of economics in the project budget, lack of law and order, and an unfavourable climate.

Srinivasan *et al.* (2022), grouped risk factors into: labour risk, material risk, credit risk, execution risk, environmental risk and planning risk. Sankar and Shashikanth (2022), categorised risk factors as cost-related risks, time-related risks, quality-related risks, environmental-related risks, design-related risks, safety-related risks, and risks due to unexpected incidents or crises.

Risk factors in construction can be categorised as technological, social, physical, economic and political (Ajator, 2014). They may be internal or external risk factors. Internal risk factors are those within the organisation's control and include its human, financial, physical, technological and managerial value and ethics. On the other hand, external risk factors are those outside the organisation's control. They are political, macro-economic, environmental, competition and multiple client project risks.

According to Kepher, Nyonje and Rambo (2022), risk factors can be viewed from the perspective of project estimates, project designs, project plans, changes in project scope and administration of projects. The success and failure of construction projects are dependent on many factors. Still, the project manager is considered to directly impact completing a project within time and budgeted cost (Dlamini and Cumberlege, 2021).

Nguyen *et al.* (2021), categorised risk factors into five groups: financial risk factors, schedule risk factors, construction risk factors, management risk factors and environmental risk factors.

From Eja and Ramegowda (2020), risk factors causing construction project failure include poor financial capacity, corruption, inaccurate costing, frequent design scope changes and errors, sociocultural and political interference, poor contracting and contractor practices, incompetence and lack of knowledge, poor planning, poor leadership, and poor communication.

Many other researchers have done further categorisation of risk factors. Chapman (2001), grouped risk into environment, industry, client and project. Risk can also be grouped into competition, technical, construction, operational, market, financial, demand, supply, institutional, regulatory, social acceptability, and sovereign risks (Miller and Lessard, 2001). Karim *et al.*, (2012) identified twenty-five risk factors and categorised them into five groups: design, construction, politics and contract provision, finance and environmental.

### **Cost estimation**

A cost estimate must address risks and uncertainties in the project. These risks and uncertainties affect the determination of the probable construction cost of a given project. It is a challenge for most construction projects in Uganda to be completed within the initial estimates. However, achieving project objectives is crucial to the parties involved and, most significantly, the client.

Cost estimating is essential for contracting and making investment decisions. When costs are overestimated, the client may decide not to proceed with the project and contractors are also likely to lose out in competitive bidding. While on the other hand, underestimation could result in the incurring of losses and project abandonment. In a study by Otim *et al.* (2011), underestimation is considered one of Uganda's leading causes of uncompleted buildings. One of the challenges in estimating for public sector construction projects in Uganda is that bidders make overly optimistic estimates to win the business.



There are different definitions of cost estimation in usage by experts and researchers. PMBOK (2013), defines cost estimation as the development of an approximation (estimate) of costs of the resources needed to complete project activities. It's the basis for project management, business planning, budget preparation and cost and schedule control (AACE, 2013). According to Choon and Ali (2008), cost estimating examines a specific scope of work and forecasts the cost of completing the work. While Butcher and Demmers (2003), see cost estimating as a well-formulated prediction of the likely cost of a specific construction project. Factors influencing cost during a construction project's conception and design stages have mainly been attributed to cost-estimating practices (Doloi, 2012). The construction industry has a poor reputation for finishing projects on budget. Nine out of ten projects usually experience cost overruns, and poor cost estimation is considered one of the leading causes (Aljohani, Ahiaga-Dagbui and Moore, 2017). In his study, Ssemwogerere (2011) asserted that most projects in Uganda are usually completed at about a 25-35 percent increase of the initial cost.

### **Risk factors in cost estimation**

In Uganda, the most severe risk factors for the cost of a construction project are poor communication between the parties, financial failure of the contractor, defective design, awarding the design to an unqualified designer, rush design, unmanaged cash flow, delayed payment on contract, inflation, occurrence of

accidents because of poor safety procedures and undocumented change orders (Umutoni, 2014).

Hatamleh *et al.*, (2018), categorised the risk factors in cost estimation as constituting consultant and contractor-related factors, factors related to market conditions and those related to project characteristics. Risk factors related to project characteristics include the financial capability of the client, site constraints (access, storage, and services), impact of project schedules, clear scope definition and project complexity. Risk factors related to market conditions include: material availability, labour cost, labour availability, equipment cost, equipment availability, equipment performance, economic climate, level of competition and level of workmanship (productivity and performance). Risk factors related to consultant and contractor were explained to include: clear and detailed drawings and specifications, experience of pricing projects, accuracy and reliability of cost information, project team experience, completeness of cost information, estimating method used, quality of assumptions used in preparing the estimate, time allowed for preparing cost estimates, contractor bidding strategy and the perception of estimation importance.

In a study carried out among building contractors by Mahamid (2014), he grouped the risk factors in cost estimation into five groups: cost estimating, construction items, construction parties, environmental and financing. Risk factors in the cost estimating group include the cost of materials, cost of labour, cost of

machinery, transportation cost, high machinery maintenance cost, high-interest rates by bankers, wrong estimation method, cost of insurance, fluctuation of prices of materials, long period between design and time of implementation, bureaucracy in tendering method and waste on-site. Risk factors related to construction items include lack of adequate human resources, frequent changes in design, contractual procedure, duration of the contract period, fraudulent practices and kickbacks, additional work and contract management. Risk factors related to construction parties include on-site disputes, poor financial control on site, previous contract experience, the relationship between managers and labourers, lack of coordination between construction parties and poor planning. Environmental risk factors in cost estimation include weather effects, poor productivity, economic instability, level of competitors, number of ongoing projects, number of competitors, project location, social and cultural impacts, inadequate raw materials, absence of construction cost data and government policies. Financial risk factors include: inflationary pressure, project financing and fluctuation in currency exchange rates.

Xie *et al.* (2022), identified sixty-five risk factors and classified them into four groups: project management, project macro, project environment and core stakeholders. According to Atapattu, Domingo and Sutrisna (2023), the risk factors with the most significant effect on the cost of construction projects are: project management, risk assessment, cost-benefit analysis, construction management, time overrun, decision-making, and design/methodology/approach.

Seidu *et al.* (2022), identified the following risk factors in cost estimation: mistakes in design, unforeseen site conditions, changes in the client's brief, construction cost underestimation, improper planning, inflation, inaccurate or poor estimation, omissions and errors in the bills of quantities, contractual claims, unsuitable construction equipment and methods, force majeure, and lack of experience for contractors.

As described by Ibrahim and Mohamed (2021), the most significant risk factors affecting cost estimation are: clear and detailed drawings, specifications and project documentation, experience and skill level of the estimator, completeness of cost information (accuracy, quality and details), materials (prices, availability, quality and imports) and experience on similar projects.

According to Kwoyigah, Alagidede and Amidu (2021), cost and associated risks are an essential consideration for all construction projects. Their study showed that changes in building material prices remain the key risk factor. In contrast, other factors include changes in project specification and design, inadequate budget analysis and lack of project management skills.

Albtoush and Doh (2019), classified the risk factors into ten main groups, namely: design and contracted-related factors, estimation-related factors, planning and schedule-related factors, project management-related factors, labour-related factors, financial related factors, material and machinery-related factors,

construction phase related factors, communication-related factors and external related factors.

Oyedele (2015) explained that the risk factors in cost estimation include: political factors, economic factors (interest rate, inflation and forces of demand and supply), time of construction, location of the project, government policy, security, legal factors (litigation, taxes and other statutory payments), year of the project, nature of project, experience of the contractor, complexity of the job, detail of project brief given to consultants by the client and corruption.

Chapman (2001), categorised the risk factors into physical risk factors, construction risk factors and financial risk factors. Construction risk factors affect a project's equipment/plant and labour. They include equipment/plant availability, suitability of equipment/plant, labour productivity level, availability of materials, unforeseen adverse ground conditions, familiarity with such work, equipment breakdown, availability of experienced and skilled labour, defects resulting from poor workmanship, maintenance facilities of plant and level of supervision. Physical risk factors are related to the project's physical nature and they include incomplete design/specification, design changes, bad weather, operative accidents, theft of materials and loss due to fire outbreaks. Financial risk factors include inflation, fluctuation and cash flow stability.

Ojo and Odediran (2015), in their study, identified a total of thirty-two (32) risk factors in cost estimation and further grouped them into six (6) categories which

include: project characteristics, bidding procedure, project design, estimating process, financial and personal factors.

## **METHODOLOGY**

### **Research design**

The design adopted a mixed-method approach using quantitative and qualitative research methods. Quantitative method was used to assess the effects of the risk factors and quantify data required for the model development using the Analytic Hierarchy Process. The qualitative approach helped in understanding the risk factors and their causes.

Qualitative research seeks to understand underlying reasons, opinions and motivations to uncover trends in thought and ideas. Qualitative data can be collected through in-depth interviews, focus group discussions and key informant interviews (Wyse, 2011). Qualitative data for this study was collected through in-depth face-to-face interviews.

Quantitative research seeks to quantify a problem by generating numerical data that can be transformed into useable statistics. It is used to quantify attitudes, opinions, behaviours and other defined variables to formulate facts and uncover patterns in research. Quantitative data can be collected through face-to-face interviews, telephone, online surveys, paper surveys, online polls and systematic

observations (Wyse, 2011). Quantitative data for this study was collected using a self-administered questionnaire.

### **Target population**

The target population comprised project managers, architects, civil engineers, quantity surveyors, electrical engineers and mechanical engineers working with consultancy and construction firms with vast experience in building construction projects within Kampala City. Based on information from the Architects Registration Board, Engineers Registration Board and Surveyors Registration Board, registered and practicing architects for the year 2021 (those with valid practicing licenses) were 143, civil engineers were 717, electrical engineers were 148, mechanical engineers were 109 and quantity surveyors were 69.

### **Sample size**

The Kish (1965) formula was used to determine the sample size for each group of this study. Other researchers have used the Kish formula to determine the sample size for their studies (Adesi, Owusu-Manu and Boateng, 2019), (Bolstein and Crow, 2008) and (Ashmawi *et al.*, 2018). The Kish formula was preferred for this study because it gives better results and is more resistant to outliers than other formulas (Akinshin, 2021). The Kish formula is stated as follows:

$$n_o = \frac{pq}{s^2}$$

**Equation 1**

$$n = \frac{n_0}{1 + \frac{n_0}{N}} \quad \text{Equation 2}$$

Where:

$n_0$  is the first estimate of the sample size.

$p$  is the proportion of the characteristics being measured.

$q$  is  $1 - p$ .

$S$  is the maximum percentage of the standard error allowed for the sample mean.

$N$  is the target population size.

$n$  is the final estimate of the sample size.

Using a confidence interval of 95% and standard error of distribution at 10%, substituting 0.5 for  $p$ ,  $q$  becomes 0.5 and substituting 0.1 for  $S$  gives a value of 25 as the first estimate of the sample ( $n_0$ ).

$$n_0 = \frac{0.5 \times 0.5}{0.1^2} = 25$$

Using this number in the second equation (2) and substituting the target population size ( $N$ ) for the different groups, gives the final estimate of the sample size ( $n$ ) as shown in Table 1.

**Table 1: Sample size**



<b>Study Group</b>	<b>Study Population (N)</b>	<b>Sample Size (n)</b>	<b>Percentage (%)</b>
Project Managers	143	21	17
Architects	143	21	17
Quantity Surveyors	69	18	14
Civil Engineers	717	24	19
Electrical Engineers	148	21	17
Mechanical Engineers	109	20	16
<b>Total</b>	<b>1,329</b>	<b>125</b>	<b>100</b>

### **Sampling technique**

A purposive sampling technique was used in data collection. The respondents and key informants were purposively sampled because they had technical and specialised knowledge about the research topic.

### **Data collection methods**

The questionnaire and interview methods were used to collect data for this study.

A self-administered questionnaire was used to collect both qualitative and quantitative data from the project managers, architects, quantity surveyors, civil engineers, electrical engineers and mechanical engineers. A self-administered questionnaire is a questionnaire that is explicitly designed to be completed by a respondent without the intervention of the researcher and the primary criterion for a well-designed self-administered questionnaire is proper wording (Lavrakas, 2008). The questionnaire was designed to contain open-ended and closed-ended questions. The self-administered questionnaire was preferred because of its low cost, saving of time and respondent's convenience.

An interview is a conversation for gathering information where the interviewer who coordinates the process of the conversation asks questions and the interviewee responds to the questions. The interview method helps the researcher to collect in-depth information on people's opinions, thoughts and experiences (Easwaramoorthy and Zarinpoush, 2006). The following questions were asked concerning the main objective: "What risk management techniques do you use on construction projects?", "How effective are these techniques in risk management?", "What risk management software do you use?", "How do you manage risks during cost estimation?", "What cost estimation methods do you use?", "What cost estimation software do you use?", "Any general comment regarding improving risk management in cost estimation in the building construction industry in Uganda?"

### **Data collection instruments**

A questionnaire and interview guide were used as tools for data collection. An interview guide is used where there is a need for in-depth information from the respondents (Easwaramoorthy and Zarinpoush, 2006). The questionnaire was designed to have two parts: part I and part II. Part I of the questionnaire was created based on the risk factors in cost estimation identified through the literature review. The respondents were asked to rank them based on their frequency index, severity index and importance index to obtain the most critical risk factors. Part II of the questionnaire was used to obtain weights of the most important risk factors

using pairwise comparisons based on Saaty (1980) scale of the Analytic Hierarchy Process (AHP) as shown in Table 2.

### **Data analysis**

Statistical Package for the Social Sciences (SPSS) and Excel were used for analysing the data. Data from the collected questionnaires were first sorted, coded and entered into the SPSS software and Excel for further statistical analysis.

On the other hand, content analysis was manually conducted to analyse data collected from face-to-face interviews. According to Haggarty (1996), content analysis is a method that allows the qualitative data collected in research to be analysed systematically and reliably so that generalisations can be made from them in relation to the categories of interest to the researcher.

The severity index and frequency index of the risk factors as perceived by the respondents were calculated using the following statistical formulas:

$$\text{Severity Index (S.I) (\%)} = \sum a (n/N) * 100/5 \quad \text{Equation 3}$$

Where:

S.I is the Severity Index.

a is the scale given for each option (it ranges from 1 – 5).

n is the frequency of the response.

N is the total number of respondents.

$$\text{Frequency Index (F.I) (\%)} = \sum a (n/N) * 100/5$$

**Equation 4**

Where:

F.I is the Frequency Index.

a is the scale given for each option (it ranges from 1 – 5).

n is the frequency of the response.

N is the total number of respondents.

Importance Index (IMP.I) was used to determine the importance index of each risk factor to get the most important factors using the following formula:

$$\text{Importance Index (IMP.I) (\%)} = [F.I (\%) * S.I (\%)]/100$$

**Equation 5**

Where:

IMP.I is the Importance Index.

F.I is the Frequency Index.

S.I is the Severity Index.

### **Model development**

Many researchers (El-Touny, Ibrahim and Amer, 2014), (Idrus, Nuruddin and Rohman, 2011), (Challal and Tkiouat, 2012), (Asal, 2014), (Buerthey, 2014) and (Allahaim, Liu and Kong, 2016), have developed and proposed models for dealing with risks in cost estimation. However, most of these models are very complex, have limited and high mathematical treatment and therefore difficult to apply. As a result, they are usually neglected by construction professionals (El-Touny *et al.*, 2014). Risk-based cost estimation involves using simple or complex modelling based on inferred and probabilistic relationships among project events. The risk factors are identified and then applied to the base cost estimate through modelling (Nevada, 2021). The Analytic Hierarchy Process (AHP) developed by Saaty (1980) was used to develop the model for this research. It was selected for its reliability and ease of use.

The AHP is an effective tool for decision-making and may aid the decision-maker to set priorities and make the best decision. It is helpful in making multi-criteria decisions involving benefits, opportunities, costs and risks. The AHP has also been applied in planning, resource allocation, conflict resolution, and prediction problems (Saaty, 1980). The proposed model was developed using the following steps:

- Establishing the objectives.
- Identifying all relevant criteria.

- Decomposing the risk factors identified by structuring them into a main hierarchy of criteria and sub-criteria as shown in Figure 1.
- Developing a pairwise comparison matrix by comparing pairs of elements in each level of the hierarchy concerning every element in the higher level to establish priority weights of elements in each level of the hierarchy. The pairwise comparison reflects the judgments and relative preferences of different decision-makers based on (Saaty, 1980) scale of 1-9 as shown in Table 2.

**Table 2: Saaty's 1-9 scale of pairwise comparison**

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	Intermediate value
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	Intermediate value
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	Intermediate value
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	Intermediate value
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
1.1-1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities

**Source: Saaty (1980)**

- Normalising the matrix by totalling the numbers in each column. Each entry in the column was then divided by the column sum to get the normalised score.
- Computing priority weights of criteria and sub-criteria by totalling the numbers in each row of the normalised matrix. The sum of each row was then divided by the matrix dimension to get the priority weights.
- Checking decision consistency by computing the consistency ratio (CR).

**Table 3: Values of random consistency index**

<b>n</b>	<b>RCI</b>
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

**Source: Saaty (1980)**

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)} \quad \text{Equation 6}$$

Where "CI" is the consistency index.

Where "n" is the number of the matrix dimension.

Where " $\lambda_{\max}$ " is the consistency measure.

The consistency measure was calculated by multiplying every value in each row of the pairwise comparison matrix and then powering the values by 1/n (where n is the matrix dimension) to obtain the total row value. The total row value of all the rows was summed to get the consistency measure.

$$\mathbf{CR} = \frac{\mathbf{CI}}{\mathbf{RCI}} \quad \mathbf{Equation\ 7}$$

Where “CR” is the consistency ratio.

Where “CI” is the consistency index.

Where “RCI” is the random consistency index.

The acceptable value of the consistency ratio should be smaller or equal to 0.10. If the consistency ratio is larger than 0.10, it indicates that the judgements require re-examination.

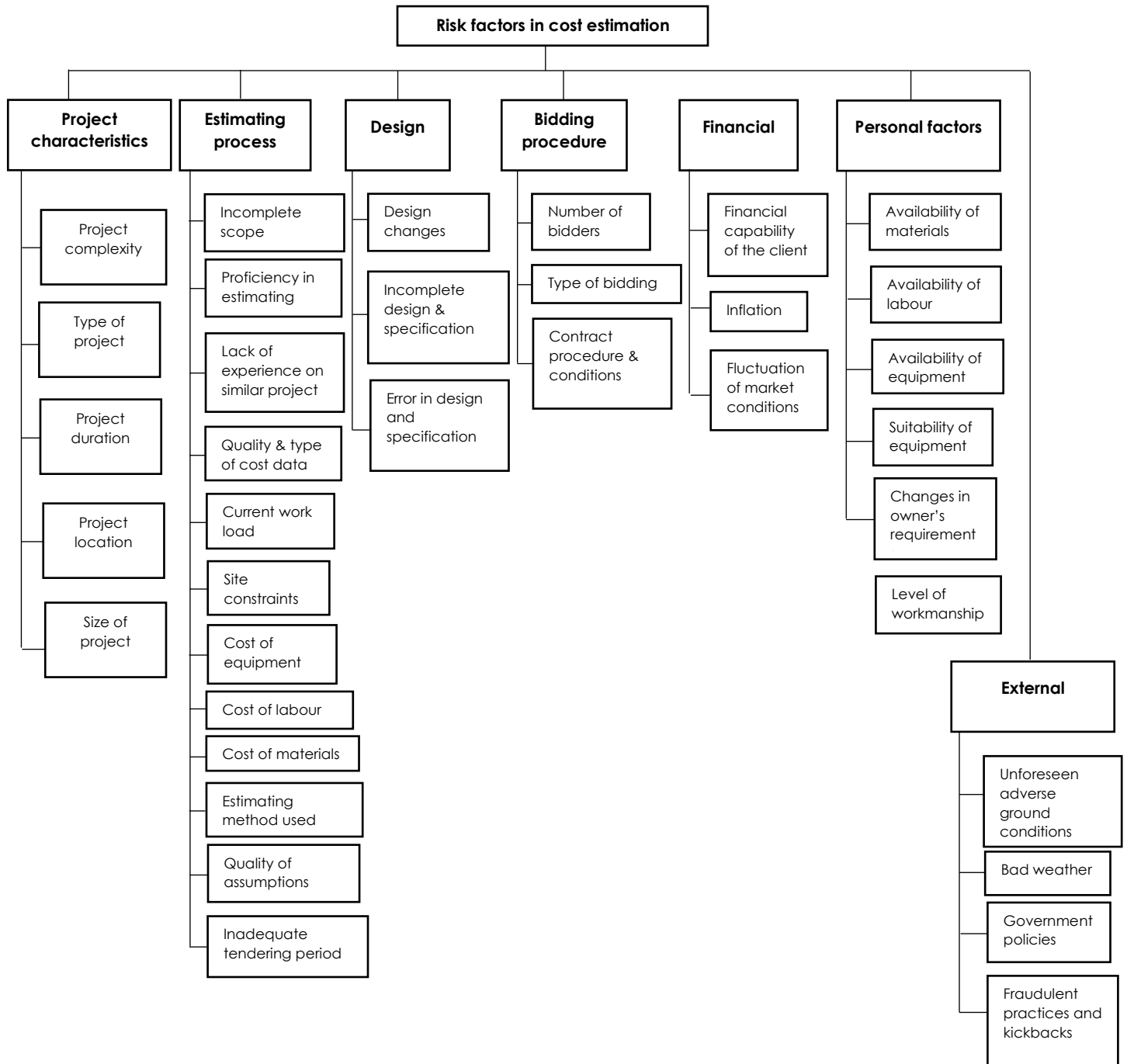
The risk-based cost estimation model was developed using the following equation;

$$\mathbf{CR} = \mathbf{RW} * \mathbf{FI} * \mathbf{SI} \quad \mathbf{Equation\ 8}$$

Where, **CR** represents the cost of risk, **RW** represents the relative weight of the factor; relative to the weight of its category; **FI** represents the frequency index of the factor; and **SI** represents the severity index of the factor.



# Risk Management in Cost Estimation



**Figure 1: Hierarchy of the thirty-six (36) risk factors in cost estimation identified through literature review**

## Model verification

Sensitivity analysis was performed to test the reliability of the developed model. Sensitivity analysis is a method used to determine the robustness of an assessment by examining the extent to which results are affected by changes in methods, models, and values of unmeasured variables or assumptions (Schneeweiss, 2006). Pichery (2014) defines sensitivity analysis as a method used to measure how the impact of uncertainties of one or more input variables can lead to uncertainties in the output variables.

## PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS

### Response rate

Self-administered questionnaires were used to get the required information from respondents. A total of 125 questionnaires were distributed, but only 108 were returned, giving a response rate of 86.4% as seen in Table 4, which according to Gordon *et al.*, (2002), is a good response rate.

**Table 4: Response rate**

Category	Sample size	Responses received	Response rate
Project Managers	21	19	90.5%
Quantity Surveyors	18	18	100.0%
Architects	21	17	81.0%
Civil Engineers	24	24	100.0%
Electrical Engineers	21	16	76.2%
Mechanical Engineers	20	14	70.0%
<b>Total</b>	<b>125</b>	<b>108</b>	<b>86.4%</b>

### Experience of the respondents

The years of experience that the respondents have in the building construction industry are shown in Table 5.

**Table 5: Experience of the respondents**

Experience	Frequency	Percentage	Cumulative percentage
Below 5 years	11	10.2	10.2
6 – 10 years	39	36.1	46.3
11 – 15 years	45	41.7	88.0
16 years and above	13	12.0	100.0
<b>Total</b>	<b>108</b>	<b>100.0</b>	

The finding in Table 5 demonstrates that the respondents had vast years of experience since a combined total of 89.8% had worked for more than 5 years and therefore believed to have provided reliable data for this study.

### Establishing the risk factors in cost estimation

Risk factors in construction projects greatly depend on the nature of the project, and identifying all the potential risk factors may be challenging. It is however possible to identify the risk factors by analysing previous studies (Riveros *et al.*, 2022). The risk factors in cost estimation were established through a literature review, which guided the questionnaire design for the study. A total of thirty-six (36) risk factors were used in the questionnaire design. The respondents were further asked to list down other risk factors based on their experience and to the

best of their knowledge. However, the responses from the respondents did not provide any additional risk factors different from those (36) already identified through the literature review.

### **Assessing the effects of the risk factors in cost estimation**

Severity Index (S.I) was used to evaluate the impact of the risk factors in cost estimation, and the factors were ranked based on the severity of their effects, as shown in Table 6.

**Table 6: Degree of severity of the risk factors in cost estimation**

No.	Risk factors in cost estimation	Degree of severity	
		Severity Index (%)	Rank
1	Project complexity	72.22	12
2	Type of project	69.26	17
3	Project duration	63.89	22
4	Project location	73.52	11
5	Size of project	69.63	15
6	Incomplete scope definition	79.81	5
7	Proficiency in estimating	83.89	2
8	Unforeseen adverse ground conditions	67.78	19
9	Lack of experience in a similar project	66.67	20
10	Quality and type of cost data	70.74	14
11	Current workload	50.19	30
12	Site constraints (access, storage, services)	62.59	23
13	Financial capability of the client	60.00	26
14	Availability of materials	77.41	7
15	Availability of labour	73.52	11
16	Availability of equipment	68.33	18
17	Suitability of equipment	60.00	26
18	Cost of equipment	67.78	19
19	Cost of labour	70.93	13
20	Cost of materials	82.96	3
21	Level of workmanship (productivity and performance)	69.44	16
22	Design changes	74.63	10
23	Bad weather	54.81	27
24	Estimation method used	61.30	25
25	Quality of assumptions used in preparing estimates	74.81	9

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26	Incomplete design and specification	82.59	4
27	Error in design and specification	75.93	8
28	Inadequate tendering period	64.07	21
29	Number of bidders	46.67	31
30	Government policies	61.48	24
31	Inflation	84.26	1
32	Fluctuation of market conditions	78.70	6
33	Type of bidding	51.67	29
34	Contract procedure and conditions	53.52	28
35	Changes in owner's requirements	70.93	13
36	Fraudulent practices and kickbacks	82.59	4

The results in Table 6 show that the risk factors with the highest degree of severity in cost estimation in the building construction industry in Uganda are; inflation (84.26%), proficiency in estimating (83.89%), cost of materials (82.96%), incomplete design and specification (82.59%), fraudulent practices and kickbacks (82.59%), incomplete scope definition (79.81%), fluctuation in market conditions (78.70%), availability of materials (77.41%), error in design and specification (75.93%), quality of assumptions used in preparing estimates (74.81%) and design changes (74.63%).

### **Frequency of occurrence of cost overruns due to the risk factors in cost estimation**

The Frequency Index (F.I) was used to determine the frequency of occurrence of cost overruns because of the risk factors in cost estimation. The factors were ranked as indicated by the respondents, and the results are shown in Table 7.

**Table 7: Frequency of occurrence of cost overruns due to the risk factors in cost estimation**

No.	Risk factors in cost estimation	Frequency of occurrence	
		Frequency Index (%)	Rank
1	Project complexity	76.11	9
2	Type of project	60.19	23
3	Project duration	69.44	13
4	Project location	61.48	21
5	Size of project	58.52	24
6	Incomplete scope definition	82.96	2
7	Proficiency in estimating	73.52	11
8	Unforeseen adverse ground conditions	70.74	12
9	Lack of experience in a similar project	66.67	16
10	Quality and type of cost data	66.67	16
11	Current workload	46.67	29
12	Site constraints (access, storage, services)	61.11	22
13	Financial capability of the client	50.93	28
14	Availability of materials	63.70	19
15	Availability of labour	65.19	18
16	Availability of equipment	62.59	20
17	Suitability of equipment	57.41	25
18	Cost of equipment	66.48	17
19	Cost of labour	78.70	7
20	Cost of materials	85.19	1
21	Level of workmanship (productivity and performance)	68.33	15
22	Design changes	82.59	3
23	Bad weather	57.41	25
24	Estimation method used	61.11	22
25	Quality of assumptions used in preparing estimates	69.07	14
26	Incomplete design and specification	76.11	9
27	Error in design and specification	81.11	5
28	Inadequate tendering period	56.11	26
29	Number of bidders	40.00	31
30	Government policies	57.41	25
31	Inflation	81.48	4
32	Fluctuation of market conditions	74.81	10
33	Type of bidding	46.48	30
34	Contract procedure and conditions	53.52	27
35	Changes in owner's requirements	77.41	8
36	Fraudulent practices and kickbacks	80.19	6

The findings in Table 7 show that the risk factors with the highest Frequency Index for the occurrence of cost overruns in the building construction industry in Uganda

are; cost of materials (85.19%), incomplete scope definition (82.96%), design changes (82.59%), inflation (81.48%), error in design and specification (81.11%), fraudulent practices and kickbacks (80.19%), cost of labour (78.70%), changes in owner's requirements (77.41%), project complexity (76.11%), incomplete design and specification (76.11%) and fluctuation of market conditions (74.81%).

### Importance Index of the risk factors in cost estimation

Importance Index (IMP.I) was used to get the most critical risk factors in cost estimation, and the findings are presented in Table 8.

**Table 8: Importance Index of the risk factors in cost estimation**

No.	Risk factors in cost estimation	F.I (%)	S.I (%)	IMP.I (%)	Rank
1	Project complexity	76.11	72.22	54.97	11
2	Type of project	60.19	69.26	41.69	24
3	Project duration	69.44	63.89	44.37	22
4	Project location	61.48	73.52	45.20	19
5	Size of project	58.52	69.63	40.75	25
6	Incomplete scope definition	82.96	79.81	66.21	4
7	Proficiency in estimating	73.52	83.89	61.68	6
8	Unforeseen adverse ground conditions	70.74	67.78	47.95	15
9	Lack of experience in a similar project	66.67	66.67	44.45	21
10	Quality and type of cost data	66.67	70.74	47.16	18
11	Current workload	46.67	50.19	23.42	35
12	Site constraints (access, storage, services)	61.11	62.59	38.25	26
13	Financial capability of the client	50.93	60.00	30.56	32
14	Availability of materials	63.70	77.41	49.31	14
15	Availability of labour	65.19	73.52	47.93	16
16	Availability of equipment	62.59	68.33	42.77	23
17	Suitability of equipment	57.41	60.00	34.45	30
18	Cost of equipment	66.48	67.78	45.06	20
19	Cost of labour	78.70	70.93	55.82	10
20	Cost of materials	85.19	82.96	70.67	1
21	Level of workmanship (productivity and performance)	68.33	69.44	47.45	17
22	Design changes	82.59	74.63	61.64	7
23	Bad weather	57.41	54.81	31.47	31
24	Estimation method used	61.11	61.30	37.46	27

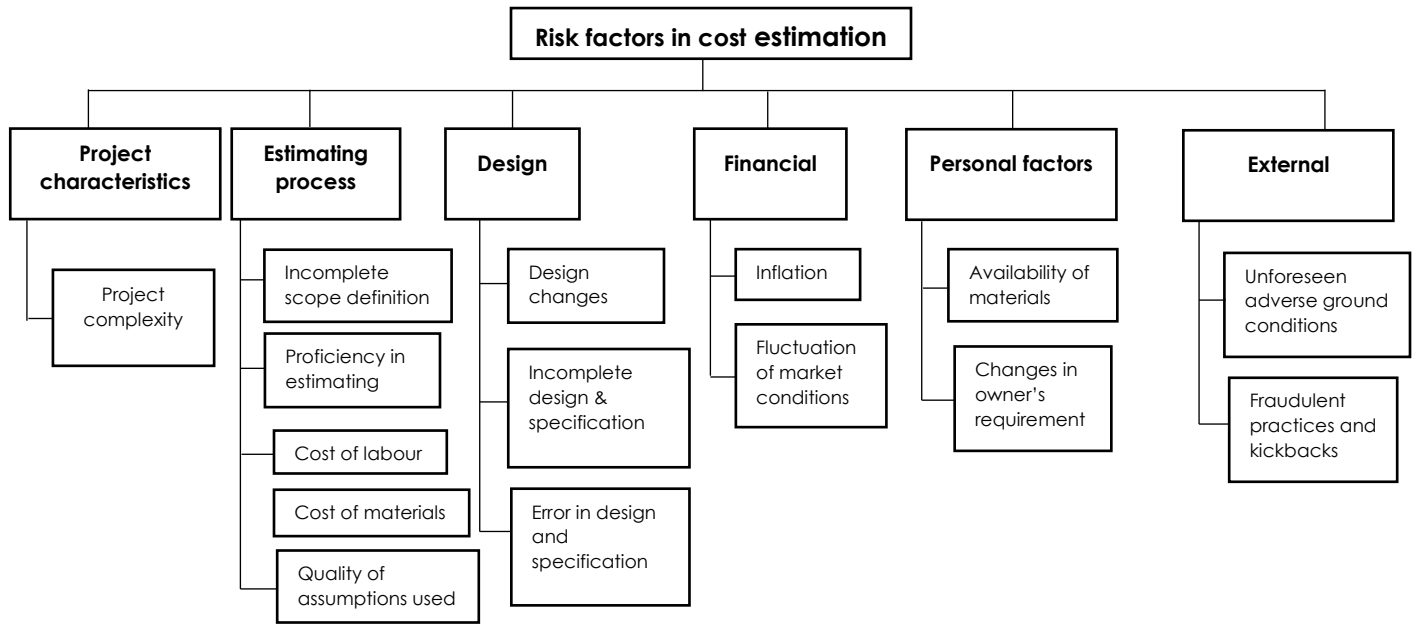
25	Quality of assumptions used in preparing estimates	69.07	74.81	51.67	13
26	Incomplete design and specification	76.11	82.59	62.86	5
27	Error in design and specification	81.11	75.93	61.59	8
28	Inadequate tendering period	56.11	64.07	35.95	28
29	Number of bidders	40.00	46.67	18.67	36
30	Government policies	57.41	61.48	35.30	29
31	Inflation	81.48	84.26	68.66	2
32	Fluctuation of market conditions	74.81	78.70	58.88	9
33	Type of bidding	46.48	51.67	24.02	34
34	Contract procedure and conditions	53.52	53.52	28.64	33
35	Changes in owner's requirements	77.41	70.93	54.91	12
36	Fraudulent practices and kickbacks	80.19	82.59	66.23	3

The results in Table 8 show that the top fifteen (15) risk factors in cost estimation in the building construction industry in Uganda are; cost of materials (70.67%), inflation (68.66%), fraudulent practices and kickbacks (66.23%), incomplete scope definition (66.21%), incomplete design and specification (62.86%), proficiency in estimating (61.68%), design changes (61.64%), error in design and specification (61.59%), fluctuation of market conditions (58.88%), cost of labour (55.82%), project complexity (54.97%), changes in owner's requirements (54.91%), quality of assumptions used in preparing estimates (51.67%), availability of materials (49.31%) and unforeseen adverse ground conditions (47.95%).

### **Developing a reliable model for risk-based cost estimation**

The model was developed based on the fifteen (15) most important risk factors in cost estimation in the building construction industry in Uganda.





**Figure 2: Hierarchy of the fifteen (15) most important risk factors in cost estimation**

### Priority weights and relative weights of the criteria and sub-criteria

The priority weights and relative weights of the criteria and sub-criteria are shown in Table 9.

**Table 9: Summary of priority weights and relative weights of the criteria and sub-criteria**

Criteria	Weight	Sub criteria	Weight	Relative weight (Wr)
<b>Project characteristics</b>	<b>0.029</b>	Project complexity	<b>1.000</b>	0.029
<b>Estimating process</b>	<b>0.226</b>	Incomplete scope definition	<b>0.491</b>	0.111
		Proficiency in estimating	<b>0.045</b>	0.010
		Cost of labour	<b>0.201</b>	0.045
		Cost of materials	<b>0.201</b>	0.045
		Quality of assumptions used	<b>0.063</b>	0.014
<b>Design</b>	<b>0.245</b>	Design changes	<b>0.261</b>	0.064
		Incomplete design and specification	<b>0.328</b>	0.080
		Error in design and specification	<b>0.411</b>	0.101
		Inflation	<b>0.500</b>	0.066

<b>Financial</b>	<b>0.131</b>	Fluctuation of market conditions	<b>0.500</b>	0.066
<b>Personal factors</b>	<b>0.278</b>	Availability of materials	<b>0.889</b>	0.247
		Changes in owner's requirements	<b>0.111</b>	0.031
<b>External</b>	<b>0.092</b>	Unforeseen adverse ground conditions	<b>0.125</b>	0.012
		Fraudulent practices and kickbacks	<b>0.875</b>	0.081

### Cost of risk for the most important risk factors

The cost of risk for the most critical risk factors was calculated based on the values of the relative weight, frequency index and severity index for each aspect as shown in Table 10.

**Table 10: Cost of risk calculated using the model**

Criteria	Sub criteria	Relative Weight (RW)	Frequency Index (FI)	Severity Index (SI)	Cost of Risk (CR = RW*FI*SI)
<b>Project characteristics</b>	Project complexity	0.029	0.761	0.722	0.016
<b>Estimating process</b>	Incomplete scope definition	0.111	0.830	0.798	0.074
	Proficiency in estimating	0.010	0.735	0.839	0.006
	Cost of labour	0.045	0.787	0.709	0.025
	Cost of materials	0.045	0.852	0.830	0.032
	Quality of assumptions used in preparing estimates	0.014	0.691	0.748	0.007
<b>Design</b>	Design changes	0.064	0.826	0.746	0.039
	Incomplete design and specification	0.080	0.761	0.826	0.050
	Error in design and specification	0.101	0.811	0.759	0.062
<b>Financial</b>	Inflation	0.066	0.815	0.843	0.045
	Fluctuation of market conditions	0.066	0.748	0.787	0.039
<b>Personal factors</b>	Availability of materials	0.247	0.637	0.774	0.122
	Changes in owner's requirements	0.031	0.774	0.709	0.017
<b>External</b>	Unforeseen adverse ground conditions	0.012	0.707	0.678	0.006

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	Fraudulent practices and kickbacks	0.081	0.802	0.826	0.054
<b>Total Cost of Risk (TCR) = <math>\sum RW * FI * SI</math></b>					<b>0.594</b>
<b>Average Cost of Risk (ACR) = <math>\frac{\sum RW * FI * SI}{15}</math></b>					<b>0.040</b>

The results in Table 10 show that the total cost of risk for the fifteen (15) most important risk factors represents 59.4% of the project cost while the average cost of risk represents 4.0% of the project cost.

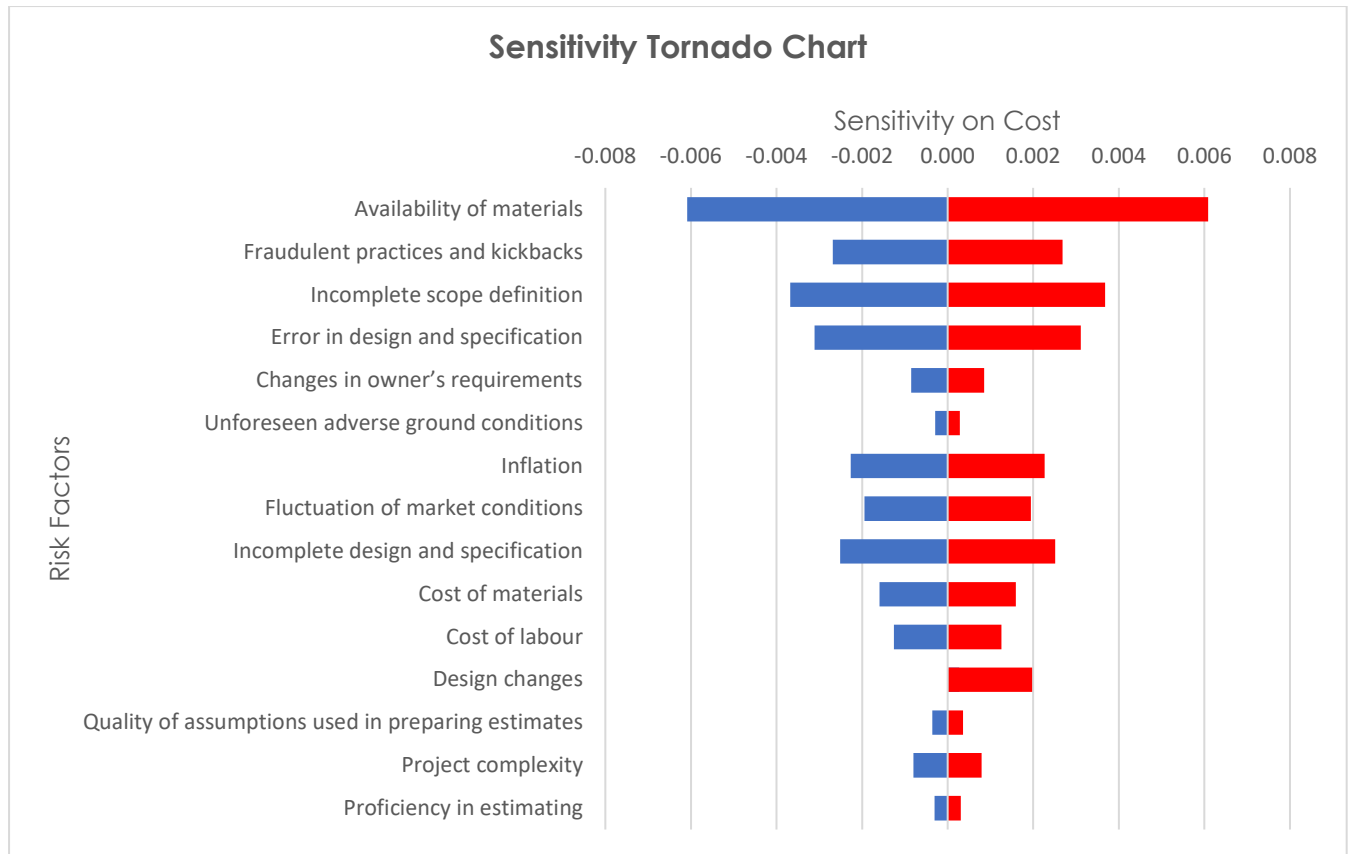
**Table 11: Cost percentages of the factors in comparison to the total cost of risk**

Factors	Cost percentage	Cumulative cost percentage	Rank
Project complexity	2.7	2.7	11
Incomplete scope definition	12.5	15.2	2
Proficiency in estimating	1.0	16.2	13
Cost of labour	4.2	20.4	9
Cost of materials	5.4	25.8	8
Quality of assumptions used in preparing estimates	1.2	27.0	12
Design changes	6.6	33.6	7
Incomplete design and specification	8.4	42.0	5
Error in design and specification	10.4	52.4	3
Inflation	7.6	60.0	6
Fluctuation of market conditions	6.6	66.6	7
Availability of materials	20.5	87.1	1
Changes in owner's requirements	2.9	90.0	10
Unforeseen adverse ground conditions	1.0	91.0	13
Fraudulent practices and kickbacks	9.1	100.0	4
<b>Total</b>	<b>100.0</b>		

The results in Table 11 show that the top five factors represent 60.9% of the total cost of risk while other factors represent 39.1%.

## **Model verification**

Sensitivity analysis was performed in Microsoft Excel to test the accuracy and robustness of the model. According to Saliccioli *et al.*, (2016), sensitivity analysis assesses how the uncertainty in the output of a model is related to the uncertainty in its inputs. Sensitivity analysis is used to quantify the uncertainty in a model, test the model and calculate the sensitivity of the model. After the analysis, the risk factors were arranged according to sensitivity to construction project cost as shown in Figure 3. Changes to the input parameters did not vary the final results about the options. Therefore, the developed model proved consistent and sensitive to the considered factors.



**Figure 3: Sensitivity analysis of the developed model**

## SUMMARY OF FINDINGS AND CONCLUSIONS

### Summary of the findings

The study revealed that the top five risk factors with the most severe effect on cost estimation in the building construction industry in Uganda are: inflation, proficiency in estimating, cost of materials, incomplete design and specification, fraudulent practices and kickbacks.

The total cost of risk estimated by the model for the fifteen most important risk factors in cost estimation in the building construction industry in Uganda represents 59.4% of the total project cost. In contrast, the average cost of risk represents 4.0% of the total project cost. Sensitivity analysis was performed on the model, which was reliable for estimating the cost of risk.

### **Conclusions of the study**

The study concluded that the top five most important risk factors in cost estimation are: cost of materials, inflation, fraudulent practices and kickbacks, incomplete scope definition and incomplete design and specification.

The study aimed to assess the effects of the risk factors in cost estimation in the building construction industry in Uganda. Therefore, according to the study, the risk factors with the most severe effects on cost estimation are inflation, proficiency in estimating, cost of materials, incomplete design and specification and fraudulent practices and kickbacks.

A reliable model for risk-based cost estimation was developed based on the Analytic Hierarchy Process (AHP). The developed model would help estimate the cost of risk on a justifiable basis, thereby eliminating the random and deterministic allocation of 0% - 10% of the project cost to cater for risks.

### **Limitations of the study**

The study was limited to only building construction projects within Kampala. Carrying out similar research in different regions of the country and also on civil engineering projects would help to understand the variation in risk factors and their associated costs. A more comprehensive testing and model application would also inform whether the findings are generalizable.

### **Contributions of the study**

Previous studies have focused on risk factors and cost overruns, but the risk factors have not been used effectively to estimate risk costs to improve project cost performance. This study has helped to reveal the need for a justifiable and defensible method of estimating the costs of risks involved in a project. Construction professionals can use the developed model to improve the accuracy of cost estimates and the general cost performance of projects.

The study has also helped to cover literature gaps by providing empirical evidence and information for further research.

## REFERENCES

AACE (2013). *AACE recommended practice and standard cost engineering terminology*, no 10s-90. AACE, inc.

Abdel-Monem, M., Alshaer, K.T. and El-Dash, K. (2022). Assessing risk factors affecting the accuracy of conceptual cost estimation in the Middle East. *Buildings*, 12(7): 950.

Adesi, M., Owusu-Manu, D.-G. and Boateng, F. (2019). Segmentation of quantity surveying professional services for focus strategy and diversification. *Journal of Financial Management of Property and Construction*, ahead-of-p.  
<https://doi.org/10.1108/JFMPC-09-2018-0052>.

Ajator, U.O. (2014). Financial engineering and project risk management: Imperatives for professional quantity surveyors. *Journal of Environment & Earth Science*, 4: 23.

Ajator, U.O. (2017). Evaluation of risk factors affecting cost performance of construction projects in Jalingo, Taraba State. *International Journal of Civil, Mechanical and Energy Science (IJCMES)*, 3(2): 138–153.

Akinshin, A. (2021). *Using Kish's effective sample size with weighted quantiles*. Available at: <https://aakinshin.net/posts/kish-ess-weighted-quantiles/#Kish1965> (Accessed: 14 March 2023).

Albtoush, A.M.F. and Doh, S.I. (2019). A review on causes of cost overrun in the construction projects. *International Journal of New Innovations in Engineering*



*and Technology*, 12(3): 15–22.

Aljohani, A., Ahiaga-Dagbui, D. and Moore, D. (2017). Construction projects cost overrun: What does the literature tell us?. *International Journal of Innovation, Management and Technology*, 8(2): 137.

Allahaim, F.S., Liu, L. and Kong, X. (2016). Developing risk-based cost contingency estimation model based on the influence of cost overrun causes. *CIB World Building Congress*, 1: 726–739. Available at: [https://opus.lib.uts.edu.au/bitstream/10453/52994/1/WBC16 Vol 3\\_paperAllahaimLiuKong.pdf](https://opus.lib.uts.edu.au/bitstream/10453/52994/1/WBC16%20Vol3_paperAllahaimLiuKong.pdf).

Asal, E.M. (2014). Factors affecting building construction projects cost estimating. *Arab Academy for Science, Technology and Maritime Transport (AASTMT)*. MS thesis, Faculty of Engineering and Technology, Arab Academy for Science, 1–87. Available at: [http://www.aast.edu/en/openfiles/opencmsfiles/pdf\\_retreive\\_cms.php?disp\\_unit=350/Emad Mohamed Asal.pdf](http://www.aast.edu/en/openfiles/opencmsfiles/pdf_retreive_cms.php?disp_unit=350/Emad%20Mohamed%20Asal.pdf).

Ashmawi, K., Hadidi, L.A., Assaf, S., Tuffaha, F.M. and Al-Ofi, K. (2018). Risk assessment and allocation in the contract for public works used in Saudi Arabia construction industry. *Cogent Engineering*. Edited by M. Hamasha, 5(1): 1–21. <https://doi.org/10.1080/23311916.2018.1490148>.

Atapattu, C., Domingo, N. and Sutrisna, M. (2023). Causes and effects of cost overruns in construction projects.

Bahati, C.M. and Kwena, R. (2023). Critical aspects influencing the construction projects' performance in Rwanda: A Case of Rubavu Modern Market. *The International Journal of Business Management and Technology*, 7(1).

Bolstein, A.R. and Crow, M. (2008). Statistical formulas and citations for EPA's 2007 ERP sample planner and ERP results analyzer. *EPA Contract Number EP-W-04-023, Work Assignment*, 3–61.

Buertey, J.I.T. (2014). Project cost risk and uncertainties: Towards a conceptual cost contingency estimation model. *International Journal of Construction Engineering and Management* 2014, 3(5): 144–155.

Butcher, N. and Demmers, L. (2003). *Cost estimating simplified*. Libris Design Project.

Challal, A. and Tkiouat, M. (2012). The design of cost estimating model of construction project: Application and simulation. *Open Journal of Accounting*, 1: 15–26. <https://doi.org/10.4236/ojacct.2012.11003>.

Chapman, R.J. (2001). The controlling influences on effective risk identification and assessment for construction design management. *International Journal of Project Management*, 19(3): 147–160.

Chileshe, N. and Kikwasi, G.J. (2013). Perception of barriers to implementing risk assessment and management practices by construction professionals in Tanzania. *Proceedings: 29th Annual Association of Researchers in Construction Management Conference, ARCOM 2013*, 1137–1146.

Choon, T.T. and Ali, K.N. (2008). A review of potential areas of construction cost estimating and identification of research gaps. *Journal Alam Bina*, 11(2): 61–72.

CoST. (2017). *The 1<sup>st</sup> Assurance Report: Uganda*. Kampala: CoST Uganda Chapter.

Dlamini, M. and Cumberlege, R. (2021). The impact of cost overruns and delays in the construction business. *IOP Conference Series: Earth and Environmental Science*. IOP Publishing, 12029.

Doloi, H. (2012). Cost overruns and failure in project management: Understanding the roles of key stakeholders in construction projects. *Journal of Construction Engineering and Management*, 139(3): 267–279.

Eja, K.M. and Ramegowda, M. (2020). Government project failure in developing countries: A review with particular reference to Nigeria. *Global Journal of Social Sciences*, 19: 35–47.

El-Touny, A.S., Ibrahim, A.H. and Amer, M.I. (2014). Estimating cost contingency for highway construction projects using analytic hierarchy process. *International Journal of Computer Science Issues (IJCSI)*, 11(6): 73.

Gordon, N., Davidoff, F., Tarnow, E., Reidenberg, M.M. and Endriss, K. (2002). A question of response rate. *Science*, 25(1): 25.

Haggarty, L. (1996). What is content analysis?. *Medical Teacher*, 18(2): 99–101.

Hatamleh, M.T., Hiyassat, M., Sweis, G.J. and Sweis, R.J. (2018). Factors affecting the accuracy of cost estimate: Case of Jordan. *Engineering, Construction and*

*Architectural Management*, 25. <https://doi.org/10.1108/ECAM-10-2016-0232>.

Herszon, L. and Keraminiyage, K. (2014). Dimensions of project complexity and their Impact on cost estimation. *Proceedings of the Project Management Institute Global Congress 2014*, 1–9.

Ibrahim, A. and Mohamed, L. (2021). Factors affecting the accuracy of construction project cost estimation in Egypt. *Jordan Journal of Civil Engineering*, 15: 329–344.

Idrus, A., Nuruddin, M. and Rohman, M. (2011). Development of project cost contingency estimation model using risk analysis and fuzzy expert system. *Expert Systems with Applications*, 38: 1501–1508.

<https://doi.org/10.1016/j.eswa.2010.07.061>.

International Organization for Standardization (2009). *ISO 31000: 2009: Risk Management: Principles and Guidelines*. International Organization for Standardization.

Kamau, S., Gesimba, P.O. and Gichuhi, D. (2022). Cost control and realization of national government constituencies development fund projects in Kikuyu constituency, Kiambu county, Kenya. *International Journal of Research in Business and Social Science* (2147-4478), 11(7): 226–233.

Abd Karim, N.A., Rahman, I.A., Memmon, A.H., Jamil, N. and Azis, A.A.A. (2012). Significant risk factors in construction projects: Contractor's perception. In 2012 *IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*. IEEE: 347–

350.

Kepher, J.A., Nyonje, R.O. and Rambo, C.M. (2022). Negotiation strategies on construction cost overruns in real estate projects: Nairobi and Kisumu counties, Kenya.

Kibwami, N. (2020). Predicting cost over-run of building projects using public procurement requirements: A case of Uganda, 9: 171–181.

<https://doi.org/10.5923/j.ijcem.20200905.04>.

Kish, L. (1965). *Survey sampling*. New York: John Wiley and Sons, Inc.

Kwoyigah, D., Alagidede, I.P. and Amidu, S. (2021). Cost performance and management styles in construction projects in the Techiman Municipality.

*Journal of Construction and Built Environment*, 1(1): 10–25.

Lavrakas, P.J. (2008). *Self-administered questionnaire*, *Encyclopedia*.

Mahamid, I. (2014). Factors affecting cost estimate accuracy: Evidence from Palestinian construction projects. *International Journal of Management Science and Engineering Management*, 10: 1–9.

<https://doi.org/10.1080/17509653.2014.925843>.

Miller, R. and Lessard, D. (2001). Understanding and managing risks in large engineering projects. *International Journal of Project Management*, 19(8): 437–443.

Muthuswamy Easwaramoorthy, F.Z. (2006). *Interviewing for research*, *Imagine Canada*.

Nevada, D.O.T. (2021). Risk management and risk-based cost estimation guidelines. no. August [Preprint].

Nguyen, P.T., Phu Pham, C., Thanh Phan, P., Bich Vu, N., Tien Ha Duong, M. and Le Hoang Thuy To Nguyen, Q. (2021). Exploring critical risk factors of office building projects. *The Journal of Asian Finance, Economics and Business*, 8(2): 309–315.

Ojo, G.K. and Odediran, S.J. (2015). Significance of construction cost estimating risks in Nigeria. *International Journal of Civil Engineering and Construction Science*, 2(1): 1–8.

Otim, G., Alinaitwe, H.M., Tindiweni, D. and Kerali, A.G. (2011). The causes and impact of uncompleted buildings; studies in Kampala City. In *Second International Conference on Advances in Engineering and Technology*.

Oyedele, O.A. (2015). Evaluation of factors affecting construction cost estimation methods in Nigeria. *From the Wisdom of the Ages to the Challenges of the Modern World, Sofia, Bulgaria*, 17–21.

Pichery, C. (2014). Sensitivity analysis.

PMBOK (2013). *Project Management Body of Knowledge PMBOK*. 5th Edition. Pennsylvania USA: Project Management Institute, Inc.

Project Management Institute (2013). *A guide to the project management body of knowledge (PMBOK Guide) - Fifth edition*. Newtown Square, PA: Author. [Preprint].

Rezakhani, P. (2012). Classifying key risk factors in construction projects. *Buletinul Institutului Politehnic din Iasi. Sectia Constructii, Arhitectura*, 58(2): 27.

Riveros, C., Ruiz, A.L., Mesa, H.A. and Guevara, J.A. (2022). Critical factors influencing early contract termination in public design–build projects in developing and emerging economies. *Buildings*, 12(5): 614.

Saaty, T.L. (1980). *The analytic hierarchy process* McGraw-Hill. New York, 324.

Saliccioli, J.D., Data, M.C., Crutain, Y., Komorowski, M. and Marshall, D.C. (2016). Sensitivity analysis and model validation. *Secondary analysis of electronic health records*, 263–271.

Sankar, D. and Shashikanth, K. (2022). Risk management in construction industry. *International Journal of Research Publication and Reviews*, 3008–3017.  
<https://doi.org/10.55248/gengpi.2022.3.5.17>.

Schneeweiss, S. (2006). Sensitivity analysis and external adjustment for unmeasured confounders in epidemiologic database studies of therapeutics. *Pharmacoepidemiology and drug safety*, 15(5): 291–303.

Seidu, R.D., Jin, R., Chen, Y., Young, B. and Ebohon, O. (2022). *Construction infrastructure project cost overrun and cost control/management techniques*. In *ASOCSA 16th Built Environment International Conference*. ASOCSA.

Srinivasan, N.P., Dinesh, A., Surajit, M. and Karthick, A. (2022). Factors influencing financial risk management in construction projects. In *IOP Conference Series: Earth and Environmental Science*. IOP Publishing, 12025.

Ssemwogerere, K. (2011). An analysis of the effectiveness of the use of contingency sum in project cost estimation & management in the Ugandan Construction industry. In *RICS Construction and Property Conference*, 1522.

Tessema, A.T., Alene, G.A. and Wolelaw, N.M. (2022). Assessment of risk factors on construction projects in gondar city, Ethiopia. *Heliyon*, 8(11): e11726.

<https://doi.org/https://doi.org/10.1016/j.heliyon.2022.e11726>.

UBOS (2021). *Statistical Abstract 2020*. Kampala.

Umutooni, B. (2014). *Risk analysis and management of construction projects in Uganda*. Makerere University.

Wyse, S.E. (2011). What is the difference between qualitative research and quantitative research. *Snap surveys* [Preprint].

Xie, W., Deng, B., Yin, Y., Lv, X. and Deng, Z. (2022). Critical factors influencing cost overrun in construction projects: A Fuzzy Synthetic Evaluation. *Buildings*, 12(11): 2028.