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Development of Strategies to Improve the Accuracy of Cost Estimates in Risk-Based Building Construction Projects

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Abstract

The cost planning process represents the initial phase of a construction project, aimed at forecasting implementation costs to enable the project owner to assess economic feasibility and evaluate alternative approaches to achieve the desired outcomes. Inadequate planning can lead to cost overruns, project delays, and even cancellations. Therefore, the cost planning process must be executed with precision, accounting for multiple risk factors to mitigate the risk of cost overruns upon project completion. Systemic risk is frequently a primary determinant affecting the accuracy of cost estimates, particularly during the early stages of project definition.

The objective of this study was to identify the most dominant systemic risk factors influencing the accuracy of cost estimates from the owner's perspective. The methodology employed combined qualitative and quantitative approaches, including surveys, expert validation, risk analysis using the Probability Impact Matrix, and a Focus Group Discussion (FGD). Data were collected via questionnaire surveys administered to 34 respondents and analyzed using SPSS software. Thirteen systemic risk factors affecting estimate accuracy were identified.

Recommended control strategies for these thirteen systemic risks include developing operational standards for risk-based estimation, establishing a unit price database grounded in the *realization price* of previous projects, conducting training programs involving experienced senior estimators, incorporating reserves or contingency allowances, and sourcing alternative materials without compromising value and functionality.

Keywords: Cost Estimation, Systemic Risk, Risk Management, Estimation Accuracy Strategy

INTRODUCTION

The construction industry is widely recognized for its poor track record in completing projects within the planned budget (Alfadil et al., 2022; Kushwaha, 2017; Moavenzadeh, 2022; Sanni-Anibire et al., 2022). Cost overrun is defined as the extent to which the final cost of a project exceeds the initial estimate (Al-Nahhas et al., 2024; Ammar et al., 2022; Shah et al., 2023). According to some studies, nine out of ten projects experience cost overruns (Abdulelah Aljohani et al., 2017). Indonesia is no exception; construction projects in Indonesia frequently face cost overruns, where the final project cost surpasses the original estimate.

One notable instance of this cost overrun phenomenon occurred in a private Indonesian company operating in the retail sector, which undertook several mall construction projects averaging four floors each. Based on the company's project implementation cost plan data, cost overruns ranged from 5.5% to 24.8%. Inaccurate cost estimating disrupts project execution, resulting in additional budget demands from owners, project delays, and even cancellations (Ekung et al., 2021; Naylor et al., 2018).

Systemic risk affects the entire project system and, according to the Association for the Advancement of Cost Engineering (AACE, 2020), is the primary risk driver impacting estimate accuracy, especially during the early phases of project definition where such risks are considered systemic.

Table 1. Risk Variables and Indicators based on AACE International (2017)

Variable Code	*Variable*	*Indicator Code*	*Indicators*	*Reference*
X1	Level of Familiarity with Technology	X1.1	Lack of knowledge of technology/estimating software leads to delays and cost overruns.	Kaming, Olomolaiye, Holt, and Haris (2010)
		X1.2	Difficulties in support (hardware, software, *experts*).	Mohamed, Kareem, and Karim (2022)
X2	Unique/remote project locations	X2.1	Poor communication due to remote areas and poor infrastructure	Mohamed, Kareem, and Karim (2022)
		X2.2	Import/export restrictions	Mohamed, Kareem, and Karim (2022)
		X2.3	Difficulties when using software and hardware	Mohamed, Kareem, and Karim (2022)
		X2.4	Improper investigation of the project site and site conditions.	Mohamed, Kareem, and Karim (2022)
		X2.5	Difficulty reaching the project site due to poor infrastructure access	Mohamed, Kareem, and Karim (2022)
X3	Project complexity	X3.1	The appearance of unexpected costs due to the complexity and size of the project.	Mohamed, Kareem, and Karim (2022)
		X3.2	Unexpected underground utilities.	Mohamed, Kareem, and Karim (2022)
X4	Cost estimation data reference quality	X4.1	Contract documents are incomplete.	Ikhsan and Leni (2021)
		X4.2	The data history is incomplete and not well managed.	Kaming, Olomolaiye, Holt, and Haris (2010)
		X4.3	Lack of pricing information based on the division of the region and the geographical conditions of the project	
X5	Quality of assumptions in estimation preparation	X5.1	Not considering all factors in the cost estimate	Mohamed, Kareem, and Karim (2022)
		X5.2	Overcost on some work items.	Shabir, Singh, Nafees, Muhammad (2017)

Variable Code	***Variable***	***Indicator Code***	***Indicators***	***Reference***
		X5.3	Inaccuracies in predicting the price of materials, tools and wages.	Kaming, Olomolaiye, Holt, and Haris (2010)
X6	Experience and skill level of estimators	X6.1	Making mistakes in estimating costs and calculating/*human errors.*	Mohamed, Kareem, and Karim (2022)
		X6.2	Low estimator skills, low wages and low productivity	Kaming, Olomolaiye, Holt, and Haris (2010)
X7	Estimation techniques	X7.1	Errors in understanding the tender documents.	Ikhsan and Leni (2021)
		X7.2	Errors in analyzing the price of work items.	Mohamed, Kareem, and Karim (2022)
X8	Time and level of effort to set up cost estimates	X8.1	Delays in the preparation or approval of submissions.	Mohamed, Kareem, and Karim (2022)
		X8.2	Lack of time in preparing for the tender stage.	Mohamed, Kareem, and Karim (2022)
X9	Market conditions & prices	X9.1	There is an increase in the cost of materials or equipment.	Mohamed, Kareem, and Karim (2022)
		X9.2	The price increase is the result of the shortage of materials in the local market.	Ibrahim Mahamid (2014)
X10	Currency value	X10.1	Currency conditions, unstable exchange rate variations.	Mohamed, Kareem, and Karim (2022)
X11	Regulatory, community, landowner & political risks	X11.1	Delay in construction permits.	Mohamed, Kareem, and Karim (2022)
		X11.2	Protests from residents around the project because the economy and lifestyle of residents are disrupted.	Mohamed, Kareem, and Karim (2022)
		X11.3	Local residents protested because the ecology of the area (river water contamination, odor, noise, and erosion) was disturbed.	Mohamed, Kareem, and Karim (2022)
X12	Third parties & utility owners	X12.1	The client/owner requests unexpected changes.	Mohamed, Kareem, and Karim (2022)
		X12.2	The director/owner makes policy changes.	Shibi, Roshini, Shreyas, Smitha, Sreeraj (2018)

Variable Code	Variable	Indicator Code	Indicators	Reference
X13	Political risk and bias	X13.1	Changes in value-added tax (VAT) regulations.	Mohamed, Kareem, and Karim (2022)
		X13.2	There is a political conflict in the country so that materials in the local market are reduced and prices rise.	Ibrahim Mahamid (2014)

Source: Processed from AACE International (2017) dan referensi terkait (Kaming et al., 2010; Mohamed et al., 2022; Ikhsan & Leni, 2021; Shabir et al., 2017; Ibrahim Mahamid, 2014)

This study critiques two prior investigations related to cost overruns in construction projects. First, the study by Abdulelah Aljohani et al. (2017) revealed that nine out of ten construction projects experienced cost overruns but did not provide an in-depth analysis of systemic risk factors or specific mitigation strategies. Second, Akintoye (1998) examined factors affecting cost estimates, such as project complexity and the availability of historical data, but did not offer a structured risk classification or conduct an impact-probability analysis. This study addresses these gaps by identifying 13 systemic risk factors, employing the Probability Impact Matrix (PMBOK, 2017) to evaluate risk levels, and validating the findings through Forum Group Discussions (FGD). Additionally, the research refers to the studies of Flyvbjerg et al. (2002) and Odeck (2004), which confirmed the prevalence of cost overruns but lacked emphasis on risk-based solutions.

The purpose of this study is to identify systemic risk events that affect the accuracy of cost estimation and to determine the dominant risk event control strategies. Based on the 13 systemic risk factors, a literature review was conducted to compile project risk events that influence accuracy and subsequently validated by 34 respondents holding positions as quantity surveyors or estimators. The questionnaire data collected constitute quantitative data analyzed using SPSS software. Risk values were calculated using the Probability Impact Matrix. Upon determining risk values and levels, final validation was conducted by experts through FGDs. These group discussions aim to produce preventative and corrective risk control strategies that are more aligned with the cost estimation practices within the owner company.

The benefits of this research include enhanced cost estimation accuracy, reduced cost overruns, and the provision of operational guidelines for project owners and estimators, such as the development of a unit price database and competency training programs. Thus, this study not only addresses gaps in the existing literature but also offers practical solutions for the construction industry's project cost management.

RESEARCH METHOD

This study uses a mixed-methods approach that combines qualitative and quantitative analysis to identify and evaluate systemic risk factors that affect the accuracy of cost estimates in construction projects. Qualitatively, this study conducted a literature review to formulate 13 risk factors based on references such as AACE International and PMBOK, and held a Forum Group Discussion (FGD) with industry experts to validate the findings and develop mitigation strategies. Meanwhile, quantitatively, this study distributed questionnaires to 34 respondents consisting of quantity surveyors, estimators, and project managers, then analyzed the data using SPSS with homogeneity tests (Kruskal-Wallis), validity tests, reliability tests (Cronbach's Alpha), and Probability Impact Matrix (PMBOK, 2017) to calculate risk values ($R = P \times I$)

and categorize them into low, medium, or high risk. The combination of these methods ensures depth of analysis through literature review and expert discussion, as well as empirical reliability through statistical testing, resulting in strategic recommendations such as the creation of a unit price database and the training of estimators to improve the accuracy of cost estimates.

The implementation of data collection was carried out on private companies that own building projects (predominantly commercial buildings, e.g., shopping centers).

The stages of the data collection method of this research use the following combined methods:

1. Literature studies and questionnaires to identify systemic risk factors.
2. Expert validation using a questionnaire with the Guttman scale and the Likert scale.
3. Risk assessment with Probability Impact Matrix (PMBOK, 2017).
4. Discussion Group Forum to develop a Systemic Risk Control Strategy.

The number of people with a job position as a quantity surveyor or estimator is 50 people. The expert criteria are project manager/QS manager and at least 10 years of work experience with the last education of S1. Then the respondents are project managers, quantity surveyors/estimators and at least 5 years of work experience with the last D3 education with the number of samples calculated based on population using the Solvin formula (Morrisan et. al., 2012). Margin of error (e) = 10% / 0.1

$$n = \frac{N}{1+(Nxe^2)}$$

So that sample respondents: or 34 people $n = \frac{50}{1+(50x0.1^2)} = 33.33$

It is done to obtain valid statements and understanding from experts that this questionnaire is appropriate and easy to understand. Respondent's expert criteria

Table 2. Respondent Profile

Position	Work Experience	Education
Senior QS / Estimator	15 years	D3
QS / Estimator	10-15 years	S1
Manager	5-10 years	S2
Project Manager	1-5 years	
Senior Manager		

Source: Primary data of the study

Results and Discussion

The questionnaire was compiled based on 13 systemic risk factors, 29 risk event indicators were divided into two stages. The questionnaire was analyzed using *SPSS software* by performing:

- Homogeneity test based on the categories of Position, Work Experience, Education
  Using the Kruskal-Wallis test where the value of
  Ho: there was no difference in perception between respondents on each variable risk factor.
  Ho is accepted if Asymp.Sig > 0.05 *(level of significant)* and Ho is rejected if Asymp.Sig < 0.05.
- **Validity and Reliability Test**

To assess the validity or invalidity of a research instrument, it can be said to be valid if the value of r calculated or *(corrected Item-Total Correlation)* is greater than the r table. If the sampling number is 34 respondents, the r table value is 0.339. Meanwhile, the reality test is carried out to find out if the measuring instrument used produces consistent measurements if re-measurements are made. The conditions for measuring the feasibility test are based on

Cronbach's Alpha value, if the Croach's Alpha value ≤ 0.5 then the research questionnaire is unreliable and vice versa

- Probability Impact Matrix

Evaluation and assessment of the impact and frequency of risk is carried out by giving weight to the level of risk based on *the Probability Impact Matrix* (PMBOK, 2017) where High Risk with a risk value of 0.2-0.727, Moderate Risk with a risk value of 0.08-0.18m and Low Risk with a risk value of 0.005-0.07.

Initial Stage Questionnaire

The purpose of the first phase of the questionnaire was to determine the systemic risk factors that affect the accuracy of cost estimates. Using the Likert scale, the level of risk influence on the accuracy of cost estimates was made by giving a score of 1-5 ranging from Very Unaffected to Very Influential.

The results of the homogeneity test for the categories of position, experience and education for 13 risk variables and 29 indicators, all categories showed an Asymp.Sig (α) value of > 0.05 so that it was concluded that there was no difference in perception between respondents.

For the validity test, the lowest calculation r has been obtained as 0.339, equal to the r-table so that it is considered valid to have a significant correlation, and for the reliability test, the lowest Cronbach's Alpha value is 0.908, which means that Cronbach's Alpha value is ≥ 0.5 so that the research data is reliable and can be used for research analysis.

Table 3. Validity and Reliability Test of the Influence of Systemic Risk

Variable		Validity and Reliability Test of Influence		
		Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Conclusion
X1.1 - X13.2	Lowest	0.339	0.908	Valid and Reliable
X1.1 - X13.2	Highest	0.819	0.917	Valid and Reliable

Source: Data analysis results using SPSS

Table 4. Recapitulation of Risk Effect Survey Results

Influence Level	Scale of Measurement	Conclusion of Response	Percentage (%)	Information
Very Unaffected	1	-	0%	Variables and indicators Have Very No Effect on the Accuracy of Project Cost Estimates
Not Influential	2	-	0%	Variables and indicators Have no effect on the accuracy of project cost estimates
Influential	3	6	21%	Variables and indicators Affect the accuracy of project cost estimates

Influence Level	Scale of Measurement	Conclusion of Response	Percentage (%)	Information
Highly Influential	4	23	79%	Variables and indicators Highly Influential on the accuracy of project cost estimates
Very Influential	5	-	0%	Variables and indicators have a great influence on the accuracy of project cost estimates
Total		29	100%	

Source: The results of the first phase of questionnaire data analysis, processed by the researcher

Based on the results of the table above, it is known that 29 indicators out of 13 risk variables have an effect on the accuracy of cost estimates, 6 indicators are influential and 23 indicators of risk events are very influential.

Phase Two Questionnaire

The second phase questionnaire aimed to determine the greatest systemic risk values by calculating the frequency and impact of the project's systemic risk factors on the accuracy of cost estimates. The number of respondent sampling and data testing is still the same as before, only the risk assessment is carried out using the Probability Impact Matrix (PMBOK, 2017). The determination of values based on the frequency Likert scale is compiled from a scale of 1-5 to find out how often risk factors occur and the impact Likert scale is compiled from a scale of 1-5 scales based on the phenomenon of cost overhead in the case study of PT X where the range of cost overhead is between 5.5% to 24.8%.

The results of the recapitulation survey of the homogeneity test of the categories of position, experience and education, all categories showed an Asymp.Sig (α) value of > 0.05 so that it was concluded that there was no difference in perception between respondents. In the validity test, the lowest r count of 0.339 is the same as the r-table so that the data is valid and correlated significantly. For the reliability test, the lowest value of Cronbach's Alpha was 0.891 which was greater than 0.5 so that the research data was reliable.

Table 5. Frequency and Impact Validity and Reliability Test Results

Variable		Frequency Validity and Reliability Test			Impact Validity and Reliability Tests		
		Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Conclusion	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Conclusion
X1.1 - X13.2	Lowest	0.339	0.891	Valid and Reliable	0.347	0.908	Valid and Reliable

X1.1 - X13. 2	Highe st	0.594	0.8959	Valid and Reliable	0.819	0.923	Valid and Reliable

Source: Results of data analysis of the second phase of questionnaire using SPSS

After the homogeneity, validation and reliability test, based on the average value of the recapitulation of the survey results of the questionnaire showed that of the 29 risk indicators, there were 12 indicators with fairly frequent frequency and 17 risk indicators with frequent occurrence during cost estimation. As for the conclusion for impact, it was concluded that there are 11 low-impact risk indicators and 19 medium-impact risks for the accuracy of cost estimates.

Table 6. Recapitulation of Survey Results on Frequency and Risk Impact

Influence Level	Scale of Measure ment	Conclusion of Response	Percent age (%)	Information
Very Rare	1	-	0%	Variables and indicators are Very Rare
Rare	2	-	0%	Rare variables and indicators
Quite Often	3	12	41%	Variables and indicators Occur Quite Frequently
Frequent Occurrences	4	17	59%	Variables and indicators Frequently Occur
Very Frequent	5	-	0%	Variables and indicators Very Frequent
Total		29	100%	

Influence Level	Scale of Measure ment	Conclusion of Response	Percent age (%)	Information
Very Low	1	-	0%	Cause a cost difference of <1% of the initial cost of the project
Low	2	11	37%	Cause a cost difference of 1%-5% of the initial cost of the project
Keep	3	18	63%	Cause a cost difference of 5%-10% of the initial cost of the project
Tall	4	-	0%	Cause a cost difference of 10%-15% of the initial cost of the project
Very High	5	-	0%	Causes a cost difference of >15% of the initial cost of the project
Total	29	100%		

Source: The results of the second phase of questionnaire data analysis were processed by the researcher

Based on the results of the frequency value (probability) and impact value, the risk value is calculated with the help of the Probability Matrix with the PMBOK formula (2017) as follows: R = P x I

R = Risk, P = Probability, I = Impact

Evaluation and assessment of the impact and frequency of risk is carried out by giving weight to the risk level, where High *Risk* with a risk value of 0.2-0.727, *Moderate Risk* with a risk value of 0.08-0.18m and Low *Risk* with a risk value of 0.005-0.07. The results of the risk assessment in this study obtained the lowest risk value of 0.05 and the highest of 0.14 which was in the medium category. In this study, no high-risk category was found, because the determination of the impact range was too wide so that the respondents' answers were in the medium or moderate range.

Table 7. Systemic Risk Matrix

Risk Level	Risk Assessment	Sum Risk Indicators	Risk Indicators
High	0.2-0.727		
Moderate	0.08-0.18	19	X2.2 X2.4 X2.5 X3.1 X4.1 X4.2 X5.2 X5.3 X7.1 X7.2 X12.1 X12.2 X3.2 X4.3 X5.1 X6.1 X6.2 X9.1 X9.2
Low	0.005 - 0.07	10	X2.1 X8.2 X11.1 X11.2 X11.3 X1.1 X1.2 X2.3 X10.1 X13.2

Source: The results of the risk matrix calculation using *the Probability Impact Matrix* (PMBOK, 2017) based on the second phase of questionnaire data

Since there is no high risk, the strategy is structured based on medium level risk. There are 8 risk variables consisting of 19 indicators of risk events or events.

X2 Unique/remote project locations

The unique and remote location of the project is a factor that affects an estimation process. Such as import/export restrictions that cause the cost of procurement of goods that are difficult to predict, it is difficult to conduct investigations or location surveys to find out the conditions, poor infrastructure causes the process to reach a difficult location and causes unexpected additional costs.

X3 Project complexity

The complexity of the project, especially the implementation method, is one of the factors that can hinder the performance of the project so that it affects the duration of the project which will ultimately have an impact on the project cost (Akintoye, 1998). The appearance of unexpected costs due to the complexity and size of the project.

X4 Cost estimation data reference quality

The reliability of compiling project cost estimates is influenced by the quality of the information used. According to Hannon (2006), databases or historical data containing information on material prices, workers' wages, tools, subcontractors and productivity from previous projects are very useful for reference in estimating the cost of future projects, so that they can improve the accuracy of QS calculations.

X5 Quality of assumptions in estimation preparation

According to Thomas (1991), the level of risk needs to be calculated based on proper assumptions, because errors in estimating the cost of risk can lead to inaccuracies in determining the unit price of materials, wages and tools.

X6 Experience and skill level estimator

The level of experience in determining the cost of a construction project is important when making assumptions that estimators use to get accurate estimates. To improve the quality of cost estimation results, good skills are also needed so that in making assumptions and cost estimates, it can be more accurate and precise.

X7 Estimation techniques

The calculation process is an important factor in determining accuracy. Arithmetic errors such as errors in using decimals, errors in multiplication can affect the accuracy rate of cost estimates. A common perception in counting or counting techniques is also needed so that the results obtained are more accurate.

X9 Market conditions & prices

The availability of goods in the market can affect the price of these goods, if goods are difficult to obtain or the stock is small, it will cause an increase in material prices so that it has an impact on other things such as wages and tools because the market price of services will also rise. Estimators must frequently update material price data according to current market conditions so that the assessment of prices can be more accurate and correct.

X12 Third parties & utility owners

The project owner's decision to change the design, specifications and rules may affect the cost estimate as the QS/Estimator will have to make readjustments, which can sometimes result in additional costs.

Discussion Group Forum (FGD)

The ultimate goal of this study is to determine the most relevant strategy by conducting a discussion forum with experts, based on risk assessment. The discussion was conducted with 3 experts in senior budget manager, manager estimator and senior estimator, with experience of over 15 years and a minimum of S1 education. Preventive and corrective control strategies were prepared as a risk response for the 19 indicators with the highest risk values obtained in this study. The results of the FGD developed in the FGD include the preparation of operational standards for the implementation of risk-based estimation, the preparation of a unit price database based on the realization of previous projects, involving estimators from the conceptual planning stage. For corrective control strategies, training can be carried out by involving competent senior estimates, adding reserve or contingency factors, looking for alternative materials without reducing benefits and usability.

CONCLUSION

This study highlights the critical role of systemic risk management in enhancing the accuracy of cost estimates, noting that systemic risks—those affecting the entire project system (AACE, 2020)—are key drivers of estimation accuracy, particularly during the early project stages. By adopting comprehensive risk control strategies, project teams can improve cost estimate precision and reduce the likelihood of cost overruns. For future research, it is recommended to explore the competencies required for quantity surveyors (QS) and estimators to ensure a shared understanding and consistent approach to cost estimation. Additionally, further investigation into variables related to field conditions and project implementation is needed to enable QS and estimators to produce more accurate cost forecasts.

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