

Cost Contingency Strategies in Building Construction: Evaluating Project Risk Influence

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ABSTRACT

Contingency costs are an important part of construction to achieve successful project management. In determining contingency costs, practitioners have used a very subjective approach. This study discussed the determination of the contingency cost of high-rise buildings in six research object projects, based on the results of risk evaluation. The risk evaluation used in this paper is based on the risks in the construction phase. The method used to know the relationship between risk and contingency costs is simple linear regression with tools. The results of this study indicate that the greater the level of risk, the greater the contingency costs incurred by the project. the risk level contributed 71.6% to the contingency cost, while the rest was influenced by other factors. The equation formed is, that if the risk increases by 1 unit, the total contingency cost will increase by 0.0916 units.

ABSTRAK

Biaya kontigensi adalah bagian penting dari konstruksi untuk mencapai manajemen proyek yang sukses. Dalam menentukan biaya kontigensi, para praktisi selama ini menggunakan pendekatan yang sangat subyektif. Penelitian ini membahas penentuan biaya kontigensi pada bangunan gedung bertingkat tinggi pada enam proyek objek penelitian, berdasarkan hasil evaluasi risiko. Evaluasi risiko yang digunakan dalam penelitian ini didasarkan pada risiko-risiko pada tahap konstruksi. Metode yang digunakan untuk mengetahui hubungan antara risiko dan biaya kontigensi adalah regresi linier sederhana dengan alat bantu. Hasil dari penelitian ini menunjukkan bahwa semakin besar tingkat risiko, maka semakin besar pula biaya kontigensi yang dikeluarkan oleh proyek. Tingkat risiko memberikan kontribusi sebesar 71,6% terhadap biaya kontigensi, sedangkan sisanya dipengaruhi oleh faktor lain. Persamaan yang terbentuk adalah, bahwa jika risiko meningkat sebesar 1 satuan, maka total biaya kontigensi akan meningkat sebesar 0,0916 satuan.

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INTRODUCTION

Contingency costs have become an important part of project management in estimating project cost budgets. Contingency costs are defined as cost reserves or cost estimates to anticipate uncertainty conditions allocated to work items based on experience and implementation of previous projects and are the integrated costs of the estimated project costs. Contingency costs are

several funds provided as reserves to deal with uncertainties and risks associated with construction projects (Fateminia & Fayek, 2023). The purpose of allocating contingency costs is to ensure that the project cost budget is estimated to be proportionally realistic and sufficient to cover costs arising from risks due to uncertainty caused by lack of information and errors in interpreting project information/data (Project Management Institute, 2021).

Several studies provide results that the range of contingency costs is 5% -25% (Salah, A., & Moselhi, 2015). But in practice, the contingency fees in the field are only in the range of 3-10% which is determined based on traditional, highly subjective methods. So errors often occur when determining contingency costs on the project. The error in determining the contingency cost can affect the contractor in preparing for or responding to the risks that arise during project implementation. The determination of too large a contingency fee can also have the impact of increasing uncompetitive bidding prices, thus allowing the contractor not to be selected during the project tender. Likewise, on the contrary, when setting contingency costs that are too small, can also minimize the profit that the contractor can get. Because of this, the contingency cost is an important matter which must be determined objectively. So that it is deemed necessary to have an accurate estimate of contingency costs.

Recently, several methods of reducing contingency costs have been widely used. Lhee et al., (2014) used the artificial neural network method to determine contingency costs. Fateminia & Fayek, (2023) used a hybrid fuzzy arithmetic-based contingency reserve model for determining contingency in incorporating risk response actions. Capone & Narbaev, (2022) used Monte Carlo simulation to propose a deterministic machine learning-based approach to estimate the Contingency Budget. Adi, T. J., & Yunwanti, (2014) conducted research on risk-based contingency cost estimation modelling in the EPC project. The results of this study have made a fairly good estimate when compared to real contingency costs. Islam et al., (2021) has also made an approach using fuzzy set theory and fuzzy Bayesian belief network model. Diab et al., (2017) developed a regression model to analyze the relationship between predetermined cost contingency amounts for highway projects and risk.

However, some of the above research focuses on the contingency cost approach to a project, not focusing on project data that has been worked on. Meanwhile, in this research, the writer wants to do a linear regression analysis that can show the relationship between project risk and contingency costs. Use of real contingency cost data combined with the results of the project risk evaluation.

RESEARCH METHOD

The risk variable as an attribute in weighting using the Fuzzy-pairwise method is taken based on the results of the literature study conducted by the author. So that the criteria used are by the conditions of the project being the object of research, it is necessary to screen the results of literature studies. The preliminary survey was conducted on three people who are practitioners in the construction sector, namely technical directors, operational directors, and Project Managers who have worked for more than 25 years in a contracting company. This survey was conducted by conducting interviews with experts to screen the risk variables obtained from the literature.

Furthermore, researchers used sampling techniques with the Quota Sampling method. This sampling technique takes the number of samples as much as the number that has been determined by the researcher. In this study, the research population is a project in 2014-2020 totaling 55 projects, which are 36 tiered buildings. The rest are warehouses, factories, bridges, and buildings other than highrise buildings. So for the sample taken 6 sample projects.

The respondents of this research are all project managers and site managers who work at a contracting company, and who are involved in highrise building construction projects. The characteristics of the respondents in this study were their level of education and experience working in the construction sector. Weighting questionnaires and risk assessments were distributed to 9 respondents represented by 1 respondent for each research object project. Respondents are

expected to be able to weigh the risks that have occurred in the research object project and provide an assessment of the risk variables and sub-variables.

Analysis is the research steps used to solve research problems and achieve research objectives. In answering the research objectives, a research stage was formed as depicted in **Figure 1**. Each step consists of the input, the process method, and the output.

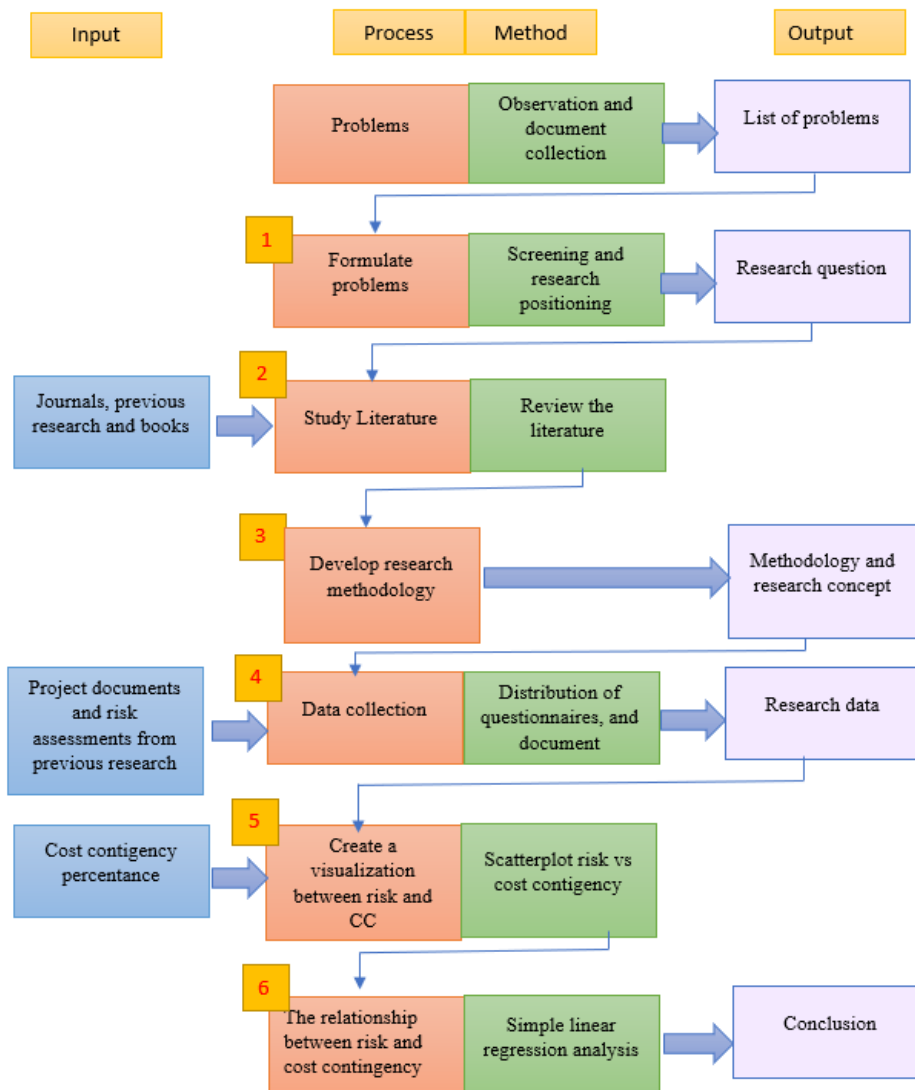


Figure 1. Research flow diagram
Source: Author (2024)

RESULT AND DISCUSSION

In this study, the research object project consisted of 6 projects undertaken by one of the contractor companies in Surabaya. The first project is a construction project for Hotel and Apartment X. This project was done in the 2014-2015 implementation period. This project consists of 2 towers of hotel and apartment buildings with 18 floors and 3 floors of basements. The next research object project is apartment Y, which was built from 2014 to 2015. This project is a construction project of 2 towers of apartment buildings with 15 floors and 2 floors of basements. The third project is the construction of the 8-floor Hospital Z building, which was done in 2017-2018. The fourth project is the construction of Hotel A in 2019-2020 in the form of 9-floor buildings. The fifth project is the construction of Funeral Home B with 9 floors of buildings, which

was built from 2019 to 2020. The last project is the construction of the C Hotel with 9 floors of buildings, which was constructed in 2019-2020.

Based on research conducted by Mawariza (2021) combination of weighted values will be carried out using a pairwise comparison of all risk variables and sub-variables to obtain the weighted value of the risk level. The results of this study indicate that the results of the risk evaluation on the six research object projects are grouped into Low-risk projects. Project 1 has a value of $\mu_{VL} = 0.0113$ with $\mu_L = 0.983$, Project 2 has a value of $\mu_L = 0.9764$ with $\mu_M = 0.0238$, project 3 has a value of $\mu_L = 0.993$ with $\mu_M = 0.0708$, Project 4 has a value of $\mu_L = 0.969$ with $\mu_M = 0.0307$, Project 5 has a value of $\mu_L = 0.9802$ with $\mu_M = 0.02$, and Project 6 has a value of $\mu_{VL} = 0.002$ with $\mu_L = 0.997$.

It can be seen the results of the recapitulation between the value of the contingency cost and the level of risk level of each project as in **Table 1**. Recapitulation of Risk Levels and Contingency Costs.

Table 1. Recapitulation of Risk Levels and Contingency Costs

Project	Real CC	Risk Level
1	2.30%	7.415
2	3.43%	7.618
3	3.24%	7.535
4	4.82%	7.652
5	3.37%	7.599
6	2.35%	7.495

Source: Author (2024)

To find out how the influence of the level of risk with the contingency cost on each project object of research, the author uses a scatterplot tool that can map the level of contingency costs and the level of risk of each project. The scatter plot is done by making the x-axis as a percentage of contingency costs and the y-axis as the risk level of each project. This can be seen in Figure 2. Scatterplot of Risk Level vs Cost Contingency. From the figure, each point that appears is a coordinate that connects the level of risk in the construction project implementation which is in ordinate y and the actual contingency costs required during project implementation in ordinate x. The same was done for all projects reviewed, namely as many as 6 projects.

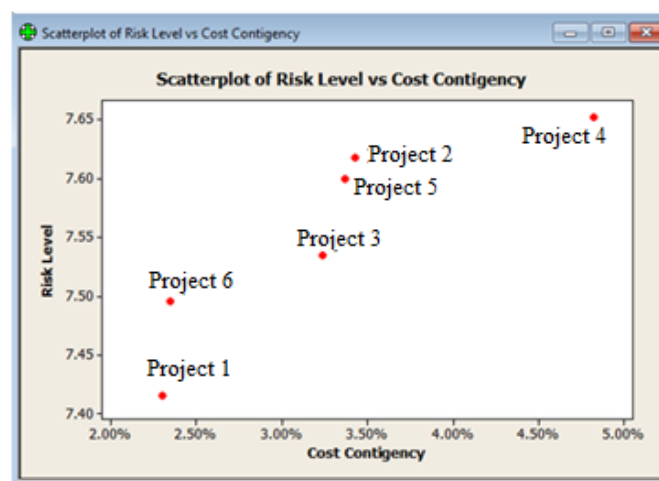


Figure 2. Scatterplot of Risk Level vs. cost Contingency

Source: Author (2024)

The scatterplot shows that the contingency costs incurred by the company in the development process are proportional to the level of implementation risk faced during development. In other words, it can be said that the greater the risk of implementation, the greater the contingency costs incurred by the company in project implementation.

In general, it can be seen from the scatterplot that the use of contingency costs will be proportional to the level of risk that occurs during the construction implementation process. The greater the risk factor, the greater the contingency costs incurred by the project. So to minimize the use of contingency costs, it is necessary to prepare preventive steps to reduce the impact and the possibility of these risks. This can be done with risk retention or risk transfer such as the use of insurance mechanisms and sub-factors. The research conducted by Abd El-Karim et al., (2017), also explains that risk responses and risk plans must be studied and controlled to transfer or mitigate the impact of these factors to other parties such as insurance companies, sub-contractors, or clients themselves, which increases the use of contingency costs that are effective and less inclined.

Seeing the relationship between risk and contingency costs, the authors make a simple linear regression to see this relationship. The first thing to do is to check the IIDN (Independent Identical with normal distribution). From the results of the check it is known that the data inputted are identical, independent, and normally distributed. This can be seen in **Figure 3**. Figure regression analysis.

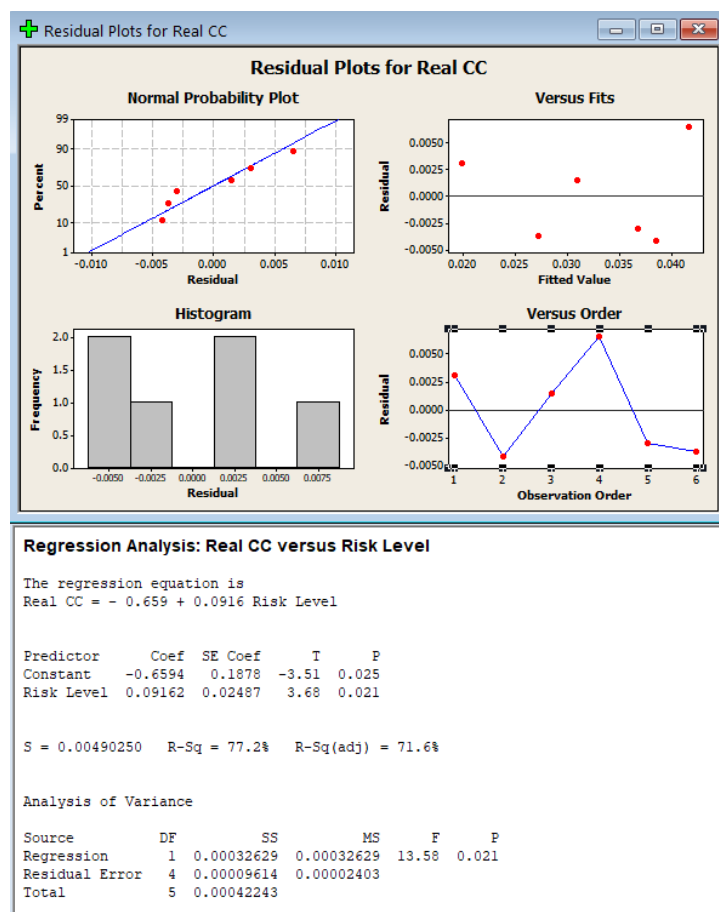


Figure 3. Simple Linear Regression Analysis
 Source: Author's Process (2024)

The residual interpretation is said to be normally distributed when it shows that the resulting points follow the linear shape of the given line. From the figure, it can be seen that from the residual data, the red dots are around the blue line, which means that the data is normally

distributed. In the figure versus fit for the independent test plot, the resulting image does not produce a pattern that widens away from the zero point, this shows that the data residuals are independent. Next is the versus fit which is used to see the homogeneity of variance. The homogeneity of variety can be concluded using the same ribbon size between the upper and lower bands. The picture shows that the upper and lower limits are 0.0050 and - 0.0050, which means that the data band and lower band are the same, which means they have a homogeneous variety. Next is the image versus the order in the image, the test results will be said to be residual identical because an image of the points that spread along the zero axis is obtained. So from the IIDN test, it can be recognized that this model has met the residual assumptions.

After carrying out the IIDN test the next step is to perform simple linear regression. From the results of simple linear regression, it is known that it is true that the risk level has a significant effect on contingency costs as evidenced by the results of the analysis having a P-value = 0.021 or less than α which is 0.05, or means H_0 rejects. The next result shows that the R-sq is 71.6%, which means that the risk level contributes 71.6% to the contingency cost, while the rest is influenced by other factors. In the simple linear regression equation, it is known that:

$$y = -0.659 + 0.0916 x \quad (1)$$

Where :

x = Risk level

y = Cost Contingency percentage

From the equation, it is known that if the risk increases by one unit, the total contingency cost will increase by 0.0916 units. Regarding, research of El-Touny et al., (2014) The developed model was tested using historical completed projects and results show that the predicted cost contingency matches 96.31% of the average estimated contingency for real case projects. Accurate estimation of the contingency cost is of critical importance to the project (Ammar et al., 2023).

In a study on a risk-based contingency cost estimation model on river normalization projects in urban areas written by Peginusa et al., (2020), the results show that there is a significant influence between the frequency of events on the effect/impact on contingency costs. Therefore, it is necessary to explore the stages in a construction project so that the types of risks can be collected thoroughly with appropriate handling. To mitigate this, usually, project implementers prepare contingency funds. Generally, the determination of the percentage of contingency costs is based on intuition by looking at past experiences and historical records of the contractor. This can be seen from the object of a research project where not all contingency costs set can cover all contingency costs that occur in the field.

Research by Shrestha & Shrestha, (2016) has also written in the study that the average percentage of contingency costs is allocated around 10% to 15% of the project cost. To improve the accuracy of the contingency estimate, the empirical distribution of the cost contingency and cost performance is examined to determine the most suitable probability distribution. The research presented in this paper shows that determining the most suitable probability distribution provides a stronger and more defensible basis for selecting cost contingencies over the traditional deterministic percentage approach. The accuracy of determining contingency costs, which is considered important in large qualifying construction companies, is not the same as that of small contractors. Affes, H., & Ayadi, (2014) said that large companies adopt innovations more easily than smaller ones because they have the capability of managing the risk, abundant available resources and a strong infrastructure.

Many contractors consider that the addition of contingency funds to the tender price of a project may result in the loss of the tender. Research conducted by Eldosouky et al., (2014) is an attempt to end this wrong opinion. A more mature attitude toward risk-responsiveness recognizes that it is possible to avoid or minimize threats and maximize opportunities. From what has been

explained contingency is very important to successfully manage a project because it provides a buffer against risk development. The cost contingency allocation technique is based on the activity's contribution to the variance of the overall cost of the project, which includes costs, uncertainty, and whether the activity is on a critical path or not. A good contingency cost management method is expected to control expenditures balance the contingency costs of project activities and estimate its future needs.

CONCLUSION AND RECOMMENDATION

Conclusion

The results of this study indicate that the greater the level of risk, the greater the contingency costs incurred by the project. The risk level contributed 71.6% to the contingency cost, while the rest was influenced by other factors. With a risk level range of 7,415 to 7,652, and a range of contingency costs between 2.30% and 4.82% of the total project contract value. The equation formed is that if the risk increases by one unit, the total contingency cost will increase by 0.0916 units.

Recommendation

With the existing limitations in this study, the authors provide suggestions for further research to achieve more perfect results. The suggestions are that future research is expected to expand the object of research and increase the number of samples that may come from different companies. As well as projects that have various risks (high, medium, and small). Further research can continue to research the correlation between the planned contingency costs and actual contingency costs, beginning from the results of the simple regression test in this study. Subsequent research can add more detailed and more sub-risk factors including secondary risk (risks that arise after carrying out a risk response). Further research can cover the scope not only of the risks of implementing construction work but also at other stages.

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