Project Cost Estimation Method for Small-Scale Construction Service Operators in Bali

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Abstract. Project planning is an important part of the realization of project implementation. In the planning stage, one of the activities that cannot be ignored is the cost estimation stage. Estimation activity is one of the main processes in a construction project to find out the amount of funds that must be provided for the completion of a project. Cost estimation plays an important role in project implementation to prevent the risk of cost overruns. Errors made in the cost estimation process can result in errors in decision making when running the project. The ability and success of contractors to survive in this fiercely competitive industry will largely depend on how well they are able to cope with uncertainty, especially in terms of costs. During the Covid-19 pandemic, many things and methods must be considered in planning project cost estimates. To find out the most widely used method by contractors to estimate costs, several contractors were conducted research using questionnaires and interviews. Data analysis in this study used the Analytical Hierarchy Process (AHP) method. The results show that the Quantity take-off method with a weight of 28.6% is in the first position, then the unit price method with a weight of 17.4%, the Elemental Cost Analysis method with a weight of 13.4%, the parameter method of 10, 7%, the method using the list price index is 10.6%, the factor method is 9.7% and the method uses the relevant project data and information with a weight of 9.6%.

Keywords: Covid-19; method; cost estimation; contractor; Bali

1. Introduction

During the Covid-19 Pandemic that hit Bali, many construction service implementers experienced problems while carrying out projects. One of the most significant constraints is project cost overruns. Swelling of project costs can be caused by wrong initial planning. In the project planning process, many things must be done, starting from preparing work plans and appointing planners and experts, considering user needs, site and field conditions, planning designs, cost estimates, and quality requirements, as well as preparing work scopes, schedules, and costs. And implementation plans. One of the most influential actors in project planning is cost estimation. Project planning is intended to bridge the gap between the goals to be achieved and the situation at the beginning [1]. At the planning stage, it is crucial to pay attention to the estimated cost of building the project because it has a broad spectrum of functions for each project participant organization with different emphases. Estimation activity is one of the main processes in a construction project to determine the funds that must be provided for a building [2]. So cost estimation plays a vital role in being able to touch the parties involved in a project, be it the owner/owner, planner, or contractor. For contractors, the

WICSTH 2022, October 28-29, Denpasar, Indonesia

DOI 10.4108/eai.28-10-2022.2328215

estimation determines the amount of the tender value and the financial benefits that will be obtained depending on how far their ability to make cost estimates is to realize the project as expected. Errors in the cost estimation process can result in errors in decision-making when running the project. The ability and success of contractors to survive in this fiercely competitive industry will largely depend on how well they can cope with uncertainty, especially in terms of costs. Therefore, the cost estimate must produce the best possible accuracy under specific project definition-level conditions [3]. During the Covid-19 pandemic, many things and methods must be considered in planning project cost estimates. The purpose of this research is to find out the methods that are often used to estimate costs that can be done to optimize cost estimates at the initial planning stage of the project so that in project implementation during a pandemic, there are no longer obstacles in the form of cost overruns caused by inaccurate cost estimates.

Regarding research on cost estimation, there have been many studies conducted by various parties that discuss cost estimation. However, each study has different characteristics depending on the chosen research theme. The cost estimation research carried out discusses various aspects, ranging from cost estimation planning, factors that support cost estimation, and methods used in conducting cost estimates to evaluating the results of cost estimates that have been carried out. This study focuses on the most widely used method for estimating costs by small-scale contractors in Bali who are still carrying out projects during the Covid-19 pandemic.

2. Method

Generally, the research methods used are presented in the flow chart.

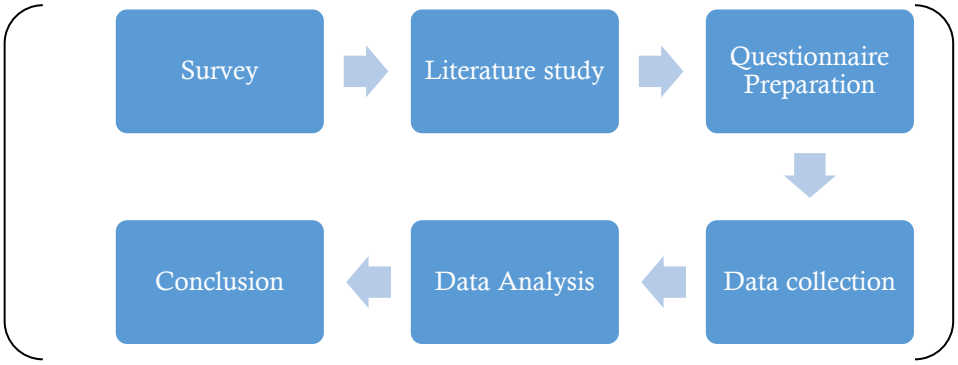

Figure 1. Research flow chart

In this study, the problem to be solved is related to the most widely used method in determining cost estimates. The questionnaires distributed and filled out by the respondents are then tabulated. In addition to making it easier to select data from many sources, data tabulation is also needed to simplify the later analysis process. After collecting data through questionnaires, the next step is data processing and analysis. The method used is the Analytical Hierarchy Process method. The steps in this method are as follows [4]:

1. Define what problems are not according to plan.
2. Create a hierarchical structure that begins with a general goal.

3. Collecting data by making questionnaires based on a hierarchical structure, then tabulating to make it easier to manage the data later.
4. Make a pairwise comparison matrix by describing each element's relative contribution or influence to each goal or criterion at the above level.
5. Perform pairwise comparisons to obtain a total of n x {(n-1)/2} judgments, where n is the element being compared.
6. After the comparison matrix for a group of elements has been formed, the next step is normalizing.
7. Determine the principal vector eigenvalues by averaging the row values for each element. After the vector eigenvalues are obtained, the next step is determining the largest vector eigenvalues (maximum). The maximum is obtained by multiplying the total matrix before normalization by the principal vector eigenvalues.
8. Check the consistency of the hierarchy. Perform synthesis (matrix iteration) to determine priority weights, and weighting is done by iteration or matrix multiplication (row x column). The iteration process is carried out until it finds a difference of 0.000 and does not change (=0) in the eigenvalues of the vector.
9. The element weights are determined to arrange priority weights into percentages (%).

After the data analysis using the Analytical Hierarchy Process method has been completed, the next step is to rank respondents' most common and most frequently used methods in estimating project costs.

3. Result and Discussion

In estimating project costs, several methods can be used by contractors/estimators in budget planning. Some of these methods include:

1. Parameter Method
2. Using a price index list
3. The method of analyzing the elements (Elemental Cost Analysis)
4. Factor method
5. Quantity take-off
6. Unit price method
7. Using the relevant project data and information

Pairwise and reciprocal comparisons (opposite) of respondents' answers consist of 21 comparisons obtained from the following formula:

$$\textit{Number of Comparisons}\ (\text{NoC}) = \frac{n.(n-1)}{2} = \frac{7.(7-1)}{2} = 21$$

Pairwise comparisons are carried out are comparing one factor to another. The results of the pairwise comparisons for each factor were tabulated and converted into a paired matrix form.

Factor	A	B	C	D	E	F	G
A	**1,000**	0,818	1,079	0,825	0,450	0,523	1,370
B	1,222	**1,000**	0,959	1,333	0,293	0,403	1,222
C	0,927	1,043	**1,000**	1,815	0,347	1,231	1,370
D	1,212	0,750	0,551	**1,000**	0,480	0,655	0,673

E	2,224	3,414	2,879	2,082	**1,000**	1,971	2,551
F	1,912	2,483	0,813	1,528	0,507	**1,000**	2,162
G	0,730	0,818	0,730	1,485	0,392	0,463	**1,000**
TOTAL	**9,227**	**10,325**	**8,010**	**10,067**	**3,470**	**6,245**	**10,350**

After the pairwise comparison matrix is obtained, the next step is to normalize the matrix.

Table 1. Matrix normalization

Factors	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**TOTAL**	**EIGEN VECTOR**
A	0,108	0,079	0,135	0,082	0,130	0,084	0,132	**0,750**	**0,107**
B	0,132	0,097	0,120	0,132	0,084	0,064	0,118	**0,749**	**0,107**
C	0,100	0,101	0,125	0,180	0,100	0,197	0,132	**0,936**	**0,134**
D	0,131	0,073	0,069	0,099	0,138	0,105	0,065	**0,680**	**0,097**
E	0,241	0,331	0,359	0,207	0,288	0,316	0,246	**1,988**	**0,284**
F	0,207	0,240	0,101	0,152	0,146	0,160	0,209	**1,216**	**0,174**
G	0,079	0,079	0,091	0,147	0,113	0,074	0,097	**0,681**	**0,097**
TOTAL	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**7,000**	**1,000**

The maximum lambda value is obtained from the algebraic matrix multiplied by the eigenvector in the first iteration. The results of these multiplications are then added together, so the maximum lambda value is 7.219. Measurement of the consistency of a matrix itself is based on the maximum eigenvalue. The consistency ratio is done to check the consistency of the hierarchy. Suppose the value is more than 10%. In that case, the judgment data assessment must be improved by improving normalization by creating a new algebraic matrix of the eigenvector values after normalization, after normalizing then looking for the eigenvector values, and looking for the maximum lambda value until a CR value of 10% is found. The value of the consistency ratio is as follows:

Consistency index (CI) = (λ maximum – n) / (n – 1)
= (9,029 – 9) / (9 – 1) = 0,003
RI = 1,45
Consistency Ratio (CR) = CI / RI
= 0,003 / 1,45 = 0,003

Based on the calculation of the consistency ratio, it can be concluded that if CR < 0.1, then the matrix is declared consistent.

The determination of element weights or priority setting in each hierarchy is carried out through an iteration process (matrix multiplication); the iteration is carried out continuously until the result of the difference between iterations is 0.000 or does not change (= 0), the iteration value obtained is then a priority order. To get the first iteration of the algebraic matrix, multiply the first row of the algebraic matrix by the first column and other. The calculation results show that the matrix iteration process is twice because the difference between the first and second iterations has fulfilled the value, which is 0.000. The difference between the vector eigenvalues in the first and second iterations can be seen in the following table:

Table 2. Eigen vector difference

Factors	First Eigen vector	Second Eigen vector	Difference
A	0,107	0,107	0,000
B	0,106	0,106	0,000
C	0,134	0,134	0,000
D	0,096	0,096	0,000
E	0,287	0,287	0,000
F	0,174	0,174	0,000
G	0,096	0,096	0,000
Total	1,000	1,000	

The weight of the elements is obtained from the value of each eigenvector in the second iteration, which is expressed in percentage weights to determine the ranking based on the largest to the lowest eigenvector values. Based on the results of data processing from questionnaires obtained using the AHP method, the order/ranking of the most widely used methods by contractors in estimating project costs is obtained. The ranking order is presented in the following table.

Table 3. Weights and Ranking of Cost Estimation Methods

Factors	Percentage	Ranking
Parameter Method	0,107 (10,7%)	**4**
Using a price index list	0,106 (10,6%)	**5**
The method of analyzing the elements (Elemental Cost Analysis)	0,134 (13,4%)	**3**
Factor method	0,097 (9,7%)	**6**
Quantity take-off	0,286 (28,6%)	**1**
Unit price method	0,174 (17,4%)	**2**
Using the relevant project data and information	0,096 (9,6%)	**7**

4. Conclusion

Based on the research that has been conducted on small-scale construction service actors in Bali, it can be concluded that the most widely used methods for estimating project costs in order are as follows: the Quantity take-off method with a weight of 28.6%, the unit price method with a weight of 28.6%. 17.4%, the Elemental Cost Analysis method with a weight of 13.4%, the parameter method weights 10.7%, the method uses a price index list with a weight of 10.6%, and the factor method is 9.7% and the using the relevant project data and information with a weight of 9.6%.

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