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The Analysis of Cost Estimation using Cost Significant Model on Bridge Construction in South Sulawesi

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Abstract. One of the fundamental problems faced by the province of South Sulawesi is the factor of accessibility, so the role of bridges is quite important. For this reason, the budget planning for standard bridge construction projects also needs to be efficient in terms of preparation and accurate in terms of budget. The Cost Significant Model is one of the total construction cost estimation models that relies more on the prices that have the most influence on the total project cost as the basis for estimation. In general, this study uses data from steel frame bridge construction projects in South Sulawesi Province to formulate a mathematical model with linear regression analysis so that it can be used in the process of estimating similar projects going forward. The Estimation Model which is formed from the regression analysis and the Cost Significant Model in this study, namely: $Y = 2,884 (X7) + 0,989 (X8) - 65515,372$. With: Y = Estimated Total Cost (Rp/m); $X7$ = Reinforcement Work Cost (Rp/m); $X8$ = Steel Frame Structure Work Cost (Rp/m). Where this model can explain 99.7% of the total project cost with a cost model factor of 1.038. The level of accuracy (percentage error estimate) of the estimation results of the Cost Significant Model in this study ranges from -1.46% to +2.45%.

1. Introduction

One of the fundamental problems facing the province of South Sulawesi is the accessibility factor, where most of the area is hills or through the river so that the role of the bridge is quite important [1]. Given that it takes a lot rebuild or build new facilities such as bridges, so that project budget planning standard bridge construction as well need to be efficient in terms of preparation and accurate in terms of financing. As an attempt to fulfill need for efficiency, then engineering making a cost estimation model simple ones need to be developed. Thing which is important in modeling cost estimation at an early stage [2]. Project planning should be easy in use, accurate and generate estimates that can accounted for. A length the bridge shows characteristics and the physical size of a project bridge construction, which is deep practically this information is readily available easily in the early stages project planning so that it is can be a reference for a model conceptual estimation.

Cost Significant Model is one of the methods that can be used in the estimation phase of a project construction [3]. In general, this method use data from projects similar construction for formulate a mathematical model so that it can be used in the process estimation. The method estimation model Cost Significant Model to be developed in this study with the hope of giving an answer against demands for a model availability estimated cost of truss bridge construction steel in South Sulawesi province. The objectives to be achieved from this research are knowing about the



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concept of the Cost Significant Model in the construction of steel frame bridges in South Sulawesi province and its estimation model and knowing what is the level of accuracy of the Estimated Cost Significant Model to the actual project costs.

2. Literature Review

The preparation of the development budget of a project requires accuracy in the estimated costs, the estimated costs play an important role in budgeting. The estimated cost is one of the construction processes to know the magnitude of the cost to the completion of a project [3-4]. On a construction project in the Government estimated cost is calculated based on the quantity of the results of calculation of the plan implemented by the image consultant Planner. However, in certain cases, e.g., natural disaster floods or landslides that resulted in a bridge collapse and the bridge is vital access which must be quickly dealt with, then the required speed of handling [5-9]. To handle such cases required speed and accuracy estimation of the costs for the budgeting on the construction of the bridge cost estimation process, building upon the very structure of the effect in the amount of the fee required. The types of building structures commonly used for the construction of the bridge. The estimated cost of the construction of bridge structures over it using concrete pressurising. The methods that will be used to examine the cost estimation is a Significant Cost Model [5].

Although the unit of observation varies across countries and methods it is recommended that the choice of data collection of a particular cost category should be mainly driven by the ability of farmers to report reliable data. For cost categories used to produce several commodities, the collected data should be per group of commodities or at the whole farm level, with an allocation formula applied to split these costs to a specific unit of observation. For example, cost items such as seeds and fertilizers can be relatively accurately collected per commodity from farmers directly, whereas overhead costs on buildings and machinery can be best collected at the whole farm level or group of commodities for which they are used. According to Heinrich, et al. (1996) [5], there are two types of models that are commonly known, namely micromorphous and paramorphous models. As shown in figure 1, the classification model from AACE International.

Table 1 The Classification of Cost Estimating Method AACE International

Estimation Class	End Usage (Typical Purpose of Estimate)	Methodology (Typical Estimating Method)	Expected Accuracy Range (Typical Low and High Range)
Class 5	Concept Screening	Capacity Factored, Parametric Model, Judgement or Analogy	Low -20% to -50% High +30% to +100%
Class 4	Study of Feasibility	Equipment Factored and Judgement	Low -15% to -30% High +20% to 50%
Class 3	Budget, Authorization, or Control	Semi Detailed Cost with Assembly Level Line Items	Low -10% to -20% High +10% to +30%
Class 2	Control Bid or Tender	Detailed Unit Cost with Force Take off	Low -5% to -15% High +5% to +20%
Class 1	Check Estimate Bid or Tender	Detailed Unit Cost with Detail Task Off	Low -3% to -10% High +3% to +15%

A micromorphous model is a model that is visual, physically real, for example a planetarium, computer simulation, or flowchart of a process. Meanwhile, the paramorphic model is a symbolic model that usually uses verbal descriptions. Paramorphous models are divided into 3 types, namely: Conceptual Model, Procedural Model, Mathematical Model According to Isimawan Dipohusodo (1996) estimation is basically an attempt to assess and estimate a value through computational analysis and based on experience [3]. Thus, estimating construction costs is the process of estimating the cost of construction based on analysis of calculations and data on previous construction projects.

In general, it is a construction structure that functions to connect two parts of a road that have been cut off due to several conditions such as deep valleys, river channels, lakes, irrigation channels, rivers, railways, roadways that are not parallel and others. Meanwhile, according to experts, a bridge is a structure that allows transportation routes across rivers, lakes, times, roads, railways, and others. The Cost Significant Model is one of the total construction cost estimation models based on past construction data, which relies more on the prices that are most influential in the total project cost as the basis for estimation, which is translated into the formulation of multiple regressions. The advantage of the Cost Significant Model is that it can predict project costs easily, quickly, and quite accurately, even though job descriptions and specifications are not available. The Cost Significant Model is based on data and information with 20% of the most expensive work materials contained in 80% of the total project cost value. This is commonly known as the 80/20 rule or the Pareto Principle [7-9].

Regression analysis is used to draw a line that shows the direction of the relationship between variables and is used to make predictions. This analysis is used to examine the relationship between two or more variables, especially to investigate the pattern of relationships whose models are not yet fully known. Regression which consists of one independent variable and one dependent variable is called simple linear regression, while regression with more than one independent variable is called multiple regression [2]. As the basis of the Significant Cost Model, it is to rely on well-documented findings that 80% of the total value of the project contained in 20% of the most expensive work items. For projects that have similar characteristics, costly items are roughly the same. Cost significant items can be collected using a variety of techniques into the same number of cost significant work items, which can present the exact proportion of the total budget costs that are usually close to 80%. The total value of the project can usually be calculated by multiplying the total price of the cost-significant packages with the right factor, approaching 1.25. The value of these factors varies depending on the category and analysis of historical data. Plans of planned work can reflect field implementation. Thus feedback and control can be facilitated. In common, it is only about 10% of the total items from conventional budgets. Simplification of this model reduces the time for Estimating costs compared to traditional cost budgets, which can consist of thousands of items. Cost Significant Models can be used to estimate costs better than 5%, and the final calculation is better than 1%. The accuracy can be increased or decreased by improving the model and depending on the data which are available.

3. Materials and Methodology

3.1. Materials

In general, this research uses the Cost Significant Method. The model with the object being reviewed is the Steel Frame Bridge Project in South Sulawesi Province which is translated into the formulation of multiple regressions. This research based on its function is a sampling method. This study took samples in several areas of South Sulawesi Province in the form of secondary data collected through South Sulawesi P2JN. The research object is a Steel Frame Bridge with the required data in the form of a Budget Plan (RAB) for several steel frame bridge construction projects under review. The data in this study are secondary data, namely the financial project data steel frame bridge the result of Engineering Estimate from the planning consultant. Data was collected with the following references:

1. The data collected is a list of project quantities and prices from several steel frame bridge construction packages in South Sulawesi Province.
2. The component prices for the work costs and the cost of implementing the work compiled do not include Value Added Tax (VAT).

3.2. Methodology

This study uses the work unit price as the independent variable. The independent variable is a component of the work carried out on the steel frame bridge project. Meanwhile, the dependent variable (Y) in this study is the total real cost of the work.

The effect of time value needs to be considered if the project data used as research data comes from different budget years. The effect of time value is calculated based on the decrease in the value of money due to the inflation factor each year. The project value is projected to the most recent year with the Future Value equation, i.e.

$$F = P(1+i)^n \quad (1)$$

With:

F = the price value in the projection which is determined

P = pre-projected price

i = inflation factor

n = distance of the projection year

To find the significant cost of items, first look for the proportion of each variable. The equation used is:

$$\text{Proporsi} = \frac{X}{y} \times 100\% \quad (2)$$

With:

X = average total cost (Rp / m)

y = average cost of work (Rp / m)

These proportions are sorted starting from largest to smallest. The cost significant items are the largest items in the number first up to 80% of the total project cost. The model needed is a model that can best explain the dependent variable's behavior based on the independent variable. This study uses the backward elimination method with the help of the SPSS program. After the formation of several models, a series of regression model tests were used, including the multicollinearity test, heteroscedasticity test, autocorrelation test, and normality test. The feasibility of the regression model to be used in estimating the value of the dependent variable is seen from the results of the ANOVA test and t-tested. The t test explains the effect of each independent variable partially (alone) on the dependent variable, while the F test explains the effect of each independent variable simultaneously (collectively) on the dependent variable. In order for the results to be more accurate, a correction factor is needed to divide the estimation results. The correction factor is the Cost Model Factor, which is the ratio between the estimated cost of the model and the actual cost. The level of accuracy is indicated by the percentage margin between the estimated price and the actual price. The equation used to calculate the level of accuracy according to Poh and Homer (1995) is:

$$\text{Accuration} = \frac{EV - AV}{AV} \times 100\% \quad (3)$$

With:

EV = esmated bill value (predicted cost)

AV = actual bill value (actual cost)

4. Results and Discussion

Each price is projected to the price in the specified year, namely 2020. As a result, the price must be adjusted to the prevailing inflation rate in that year. The inflation data used is general inflation which is obtained from the website of the Central Statistics Agency of South Sulawesi Province.

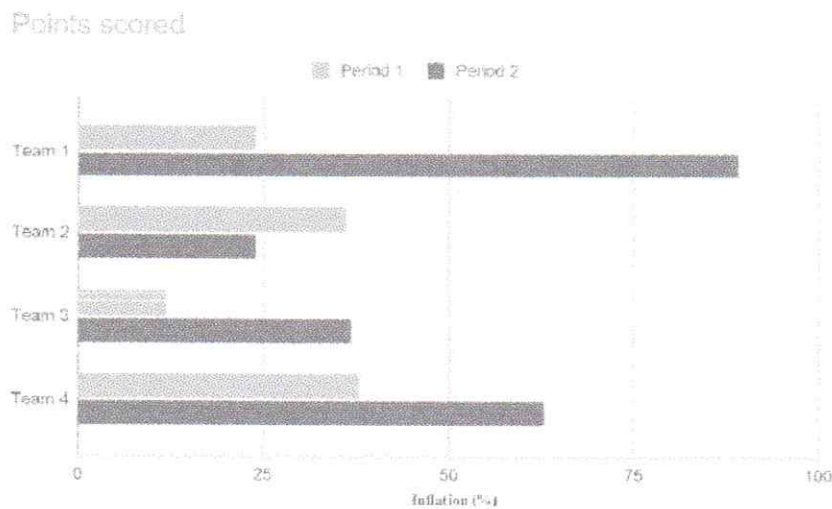


Figure 1. The Inflation Financial Data of South Sulawesi, in 2020

From Figure 1 it can be seen that the independent variables that make up > 80% of the total costs are the independent variables X4, X6, X7, and X8. Thus, the independent variables X4, X6, X7, and X8 are cost significant items. So, the data to be processed with the SPSS program is Y as the dependent variable, and X4, X6, X7, and X8 as the independent variable.

In determining the linear regression model, this study uses the backward elimination method. Against the independent variables, namely the cost of the significant cost of the item and the dependent variable, namely the total cost. The resulting regression model is shown in Table 2.

Table 2. Choice of Regression Model with Backward Elimination Method

Model	Unstandardized Coefficients B	Model	Unstandardized Coefficients B	Approval
(Constant)	-13582436.339	(Constant)	-28954140.163	.app
X4	-.738	X6	2.081	.app
X6	2.037	X7	2.835	.app
X7	3.276	X8	1.148	.app
X8	1.016	(CONSTANT)	-65515.372	.app
		X8	.989	done

The Cost Significant Model is obtained by dividing the cost of the estimation model by the CMF. Meanwhile, the level of accuracy is calculated by dividing the difference between estimated costs and actual costs by actual costs, then multiplying by 100%. Estimation of the Cost Significant Model and its level of accuracy are shown in Table 3.

Table 3. Calculation of Estimated Cost Factor Model

No.	Estimation of Total Final Cost (Y)	Estimation of Cost Significant Model CMF (1,038) Rp	Actual Total Cost (Y) Rp.	Accuracy %
[1]	[2]	[3] = [2] · CMF	[4]	$\frac{[5] = ([3] - [4])}{[4]} \times 100\%$
1	Rp 11,732,628,258.81	Rp 11,304,737,950.14	Rp 11,263,251,616.13	0.37
2	Rp 11,122,597,581.06	Rp 10,716,955,161.71	Rp 10,875,828,945.06	-1.46
3	Rp 10,025,858,791.85	Rp 9,600,214,562.89	Rp 9,787,792,004.45	-1.30
4	Rp 23,431,211,648.59	Rp 24,303,732,420.59	Rp 23,916,897,570.56	2.45
5	Rp 13,694,716,235.88	Rp 13,192,376,798.43	Rp 13,200,600,003.04	-0.06
		Min		-1.46
		Max		2.45

The level of accuracy of the Cost Significant Model estimation results ranges from -1.46% to +2.45%. The level of accuracy (percentage error estimate) that is positive indicates that the total cost estimate is greater than the actual total cost.

5. Conclusion

Based on the results of this study, the following conclusions can be drawn, in the steel frame structure bridge project in South Sulawesi, the work that uses the largest cost to the total project cost includes grained pavement work, concrete work, and especially on reinforcing work and steel frame work. The Estimation Model formed from the regression analysis and the Cost Significant Model in this study are:

$$\text{Model: } Y = 3,884 (X7) + 0,989 (X8) - 65515,372$$

With 99.7% of the total project cost and the cost model factor of 1.038.

The level of accuracy (percentage error estimate) of the estimation results of the Cost Significant Model in this study ranges from -1.46% to +2.45%. The grade is in class 1 of the AACE International Classification which has a lower limit of -3% to -10% and an upper limit of +3% to +15%. This explains that the estimation model is feasible for both a feasibility study and a bid estimate. So that in preparing a similar project, this research can be a reference that a CSM estimation method for steel frame bridges can predict the total project cost easily, and quite accurately, only with the most influential work price and the planned bridge span.

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