Journal of Asian Scientific Research
ISSN(e): 2223-1331/ISSN(p): 2226-5724

journal homepage: http://www.aessweb.com/journals/5003

TIME-COST RELATIONSHIP MODEL ON THE CONSTRUCTION OF EDUCATION BUILDING IN ACEH PROVINCE

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ABSTRACT

Time and cost are two important things in the implementation of construction projects. The greater the volume of the building will increase the period of implementation so that the higher the cost. Time and transaction costs provides challenges, and in the same time also opportunities for the construction planners to prepare the best construction plan with the optimal time and cost in order to complete the projects implementation. This research aims to obtain a relationship model of time, cost, and volume of the construction of Education Building in Aceh Province, particularly in the area of Bireun, Pidie, Aceh Utara, Aceh Selatan, Aceh Barat, Aceh Timur, Aceh Tengah, and Aceh Besar/Banda Aceh. The study is limited on the single storey building. The collected data as RAB, appointment/PHO, and images were obtained from the Education Department of Aceh province from 2008-2009 fiscal year resulted 105 (one hundred and five) projects, consist of Kindergarten/Early Childhood, Elementary, Junior High and Senior High school. This research involved the statistical calculation approach of Bromillow equation model and multiple regression analysis. The output indicates that the relationship of time and cost in those eight regions are exist (Model Bromillow). But, the recommended areas are only in Aceh Utara/Lhokseumawe at T = 12.75 C0, 26, and Aceh Barat at T = 6.68 C0, 36. As the result, the relationship model of cost, time, and volume is Y = 37.729 + 0.035X1 + 0.021X2 in Aceh Utara/Lhokseumawe. The finding of the relationship of those three models are recommended based on the linear hypothesis testing and the level of validation is <15%.

Keywords: Time, Cost, Volume, Simple Regression, Multiple Regression, *Bromillow* Model

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DOI: 10.18488/journal.2/2015.5.7/2.7.328.339
ISSN(e): 2223-1331/ISSN(p): 2226-5724

1. INTRODUCTION

In the construction projects, time and cost have a very close relationship. That relationship can be illustrated in a linear fashion, which means for the same type of project, the greater the volume of work the greater the cost and time are required in order to complete the whole project. Time and cost are two major things in the implementation of construction projects. Contractors usually use previous experience in estimating the period and cost of a new project. Transaction costs and time provides challenges and opportunities for the construction planners to set the best construction plan with the optimal time and cost in line to complete the project. Based on observations, the way to estimate the length of time that needed to complete a construction project had been be a problem. Thus, the difference and variation of execution time with the relative costs that arise in the project is similar. Depart from these problems, the researcher tried to obtain a relationship model of time and cost to predict the length of implementation time by bridging the cost and volume of the building. Based on his research in Australia in 1974, *Bromillow* found a model (T = KCB) which used to estimate the time required in order to carry out the construction projects by linking to the project costs. The purpose of this study is to review the relationship model of time and cost proposed by *Bromillow* and the relationship model of time, cost, and volume using multiple regression equation in the construction of educational buildings in Aceh Province.

2. LITERATURE

2.1. Time Concept

Fortune and White [1] stated that time is one of the most important criteria of the successful project management. In addition, the realistic schedule is a critical success factor that appears in many publications which focused on research about the success factors. Although time in the construction projects is a factor that is highly depend on the experience to arrange the time, technology, financial, and the other factors, there are some attempts to create a construction duration model based on costs that have been realized. Soeharto [2] had summarized that time is an important parameter as well as costs and resources. The level of dependency of one parameter to the others is different from one project to another. Planning and controlling the time was running by managing the schedule, that is by identifying the point when the work begins and when the job ends. In this term, project managers often assume that the sooner completion of the work is the better. To determine the duration, there are some factors need to consider: type of activity, methods of operation, location or field of activity, resources, volume of work, the flow of funds (cash flow) and inventory of materials, appliances, climate and weather, socio-political.

2.2. Time-Cost Relationship

According to Soeharto [2] in project activities between the time schedule and cost have a very close relationship. In this case, one parameter has a direct effect to the others and on the next turn will affect to the overall project. Le-Hoai, et al. [3] in his research journals in Korea explained that by using the *Bromillow* equation, the relationship of time and cost of a project with contract value of KRW 1 billion was explained. It takes about 341 working days in average to finish construction of KRW 1 billion in Korea. Compare to the private project, the public sector needs 359 days to complete their work while the private sector requires a shorter time which is less than 220 days [4]. In addition, housing project took longer (369 days) than a commercial project (225 days). If the Choudhury and Rajan [5] in Texas found that the best predictor of the average time of construction for the residential projects in Texas are (T = 18.96 C0.39). The study concluded that the project has spent 18.96 days to complete the project with a total contract of $1,000. Their study mentioned that if the calculated value of F is greater than the value of F table at the sensitivity level of 0.0001, the null hypothesis does not mean rejected.:

2.3. Construction Time Modeling

Bromillow [6] in his research has determined the relationship of time and costs in the form of formula:

$T=KC^B$

Which are:

T= Duration of the construction period

C= Construction cost (in millions of rupiah)

K= Constant that describes the efficiency of time

B= Constant that describes the utility of time that influenced by cost.

and the regression equation:

$Y=a + b_1x_1 + b_2x_2$

Which are:

Y= Time of construction (dependent variable)

a= Constant

x_1= Cost variable (independent variable)

x_2= Volume variable (independent variable)

b_1= Coefficients that influence the cost factor

b_1= Coefficient that influence the volume factor

3. RESEARCH METHODOLOGY

3.1. Location, Subject and Object of the Research

The survey was applied on the project of educational building in the western, eastern, northern and southern province of Aceh, which consists of eight areas: Bireun, Pidie, Aceh Utara/Lhokseumawe, Aceh Selatan, Aceh Timur, Aceh Tengah, and Aceh Besar /Banda Aceh.

The subject of the research is the construction of simple classification single storey educational building, from the year 2008-2009, which include Kindergarten/Early Childhood, Elementary, Junior High and Senior High school. The object of this research is time, cost and volume of the building.

3.2. Method of Data Collection

The method of data collection is by collecting the secondary data. It comes from the Education Department Office of the Provincial Government of Aceh. The number of full data 105 (one hundred and five) data from the Project in 2008-2009. The collected data involves time (appointment/PHO), RAB (budget plan) and image.

3.3. Method of Data Processing

The collected data are processed using statistical calculations of the computational tool from Excel 2007 that works in Windows XP.

3.4. Simple Regression Analysis/Bromillow

To determine the relationship of time and cost, *Bromillow* equation model which derived from the simple linear regression equation including correlation analysis was applied. Data used in the model T = KCB is the data about time and cost.

One form of non-linear regression is Y = aXb. Starting from this, geometric regression equation then can be transformed into a linear form of logarithms which then translated into native or so-called Logarithmic Naturalis, written as ln, using the nature of the original logarithmic:

1. log ab = log a + log b
2. log ab = b log a

From the relationship equation of time and cost stated by *Bromillow* $T = KCB^B$, then it can be described as follows:

$T = KCB^B$ 1

log T = log (KCB)

log T = log K + log CB

log T = log K + B log C

Logarithm log T = log K + B log C, then the statistical formula which have the same pattern to that form of logarithm formed as y = a + bx. Simple regression analysis is based on functional or causal relationship of one independent variable to one dependent variable. The formula of simple regression equation is as follows:

Y = a + bX

$$b = \frac{n\ \Sigma XY - (\Sigma X)(\Sigma Y)}{\Sigma X^2 - (\Sigma X)^2} \qquad a = \frac{\Sigma Y - b\ \Sigma X}{n}$$

One form of non-linear regression or curve is a geometric form: Y = a. .x.b . Geometric regression can be solved by a suitable transformation to become linear. The transformation used is the logarithmic form, so that the geometric form becomes: log Y = log a + b log X, which is linear in log X and log Y. In simple linear regression techniques in the form Y = a + b .x, coefficients a and b are determined by the formula (2.3) and (2.4) above. Geometric regression can be linear by using the formula above. Coefficients a and b can be determined through the log a and b and make the logarithm of the data X and Y. Log a and b are calculated after first replacing a with log a, log Y with Y and X with log X. So the formula becomes:

$$\log a = \frac{\left(\Sigma(\log Y)\right)\left(\Sigma(\log X)^2\right) - \left(\Sigma(\log X)\right)\left(\Sigma(\log X)(\log Y)\right)}{n\left(\Sigma(\log X)^2\right) - \left(\Sigma(\log X)\right)^2}$$

$$b = \frac{n\left(\Sigma(\log X)(\log Y)\right) - \left(\Sigma(\log X)\right)\left(\Sigma(\log Y)\right)}{n\left(\Sigma(\log X)^2\right) - \left(\Sigma(\log X)\right)^2}$$

3.5. Multiple Regression Analysis

Nazir [7] stated that if the parameters of a functional relationship between a dependent variable with more than one independent variable that you want to know, then the regression analysis used is multiple regression formula which developed from a simple regression. The regression formula is:

$$Y = a + b_1 X_1 + b_2 X_2 + b_n X_n$$

So the normal equation is as follows:

$$\Sigma Y = na + b_1 \Sigma X_1 + b_2 \Sigma X_2$$

$$\Sigma X_1 Y = a\Sigma X_1 + b_1 \Sigma X_1{}^2 + b_2 \Sigma X_1 X_2$$

$$\Sigma X_2 Y = a\Sigma X_2 + b_1 \Sigma X_1 X_2 + b_2 \Sigma X_2{}^2$$

3.6. Correlation Coefficient

Husin [8] suggested that the correlation coefficient is an index used to measure the degree of relationship, including the strength of the relationship that lies between -1 and 1. To shape or direction of the relationship, the correlation coefficient value is expressed in positive (+) and negative (-), or (-1 ≤ ≤ KK +1). The correlation coefficient is usually used to measure the degree of relationship of two variables is the simple correlation coefficient (simple regression) are the type of Pearson's correlation coefficient (r). The formula for calculating the Pearson correlation coefficient is:

$$r = \frac{n\,\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[n\,\Sigma X^2 - (\Sigma X)^2\right]\left[n\,\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

As for the multiple regression correlation coefficient used are

$$r^2 = \frac{b_1\,\Sigma X_1 Y + b_2\,\Sigma X_2 Y}{\Sigma Y^2}$$

that:

r = Pearson correlation coefficient

X = independent variable

Y = dependent variable

n = number of samples

3.7. Coefficient Determinant

The coefficient determinant of (KP) is used to determine the contribution of an independent variable, in this case the variable cost (C) of the variation (increase/decrease) to the dependent variable which is time (T) where the value is between 0 to 1 ($0 \leq KP \geq 1$) [9]. The equation used to calculate the KP is:

KP = $(r)^2$ x 100%

that:

KP = coefficient determinant

r = correlation coefficient

3.8. Validation

After analysis of the simple and multiple regression model, the validation performed, where the value of deviation from the value of Y count and Y model then calculated. The level of accuracy is justified by the condition of maximum error <15%, as stated by Kerzner [10] for the type estimation of approximate estimate. Validation model resulted error less than 15% could be recommended to apply to predict the unit price in the coming year. The model of unit price that can be recommended for each region is a model derived from one of simple linear regression analysis or from multiple regression analysis with the following requirements:

1. Has the largest R2 value from the two regression analysis; and
2. Have a tendency to validate the results with an error rate of less than 15% (more than 50% of the validation results that can be used from a total data collected).

3.9. Hypothesis Testing-F test

To prove the feasibility of the regression model, the F test executed by comparing F count and F table. Here all are counted by the number-sum of squares (JK) for all variety of sources of total (T), coefficient (a), regression (b | a) and residual (S) [11]. Total-sum of squares is calculated using the following formula:

$$JK(T) = \Sigma(\log Y)^2$$

$$JK(\log a) = \frac{\left(\Sigma(\log Y)\right)^2}{n} \quad (2.14)$$

$$JK(b|\log a) = b\left[\Sigma(\log X)(\log Y) - \frac{\left(\Sigma(\log X)\right)\left(\Sigma(\log Y)\right)}{n}\right] \quad (2.15)$$

$$JK(S) = JK(T) - JK(\log a) - JK(b|\log a)$$

Each source of variation has a common scale called the degrees of freedom (dK), a large n to the total, 1 for the coefficient (a), 1 for regression (b | a) and (n-2) for the remainder. With the dK and JK we can see the magnitude square of the middle (KT) obtained by dividing JK by his dK respectively. KT (b | a) is often denoted by s2reg and KT (S) is denoted by s2sis.

All the quantities obtained are arranged in a list known as the list of abbreviated ANOVA analysis of variance or simple linear regression of the arrangement are as follows:

Table-1. List of Analysis of Variance (ANOVA)

Source of variation	**dK**	**JK**	**KT**	**F**
Total	N	JK (T)	JK (T) / n	
Koef (a)	1	JK (a)	JK (a) / 1	
Reg (b|a)	1	JK (b|a)	s^2_{reg} = JK (b|a) / 1	s^2_{reg} / s^2_{sis}
Remaining	n-2	JK (S)	s^2_{sis} = JK (S) / (n-2)	

Quantities in this particular list in a column A NOVA KT, used to test the null hypothesis (the regression coefficient does not mean><coefficient of regression toward mean). The null hypothesis was tested by using the statistic F = s2reg / s2sis, and then used the distribution of the F test and the table with dK numerator 1 and denominator (n-2).

Criteria for the null hypothesis is that if the test statistic F obtained from the research is greater than the price of the F table (F research > F table) then the null hypothesis that the regression coefficient is not rejected, or the coefficient was significant. Conversely, if the F statistic obtained from the study is less than the price of the F table, the null hypothesis that the regression coefficient means is rejected, or the coefficient was not significant.

To calculate F test on the multiple regression F test using the formula:

$$F_{count} = \frac{R^2(N-k-1)}{k(1-R^2)}$$

R^2 = coefficient of determination

N = Number of data

K = Degrees of Freedom.

3.10. Hypothesis Testing - T-test.

To calculated using the equation determining the statistical value (value To):

$$t_0 = r\sqrt{\frac{n-2}{1-r^2}}$$

t_0 = value Statistical test

n = number of samples

r = correlation coefficient

By comparing the value of and t0 t table it can be determined the hypothesis (Ho) is accepted or rejected.

4. RESULT AND DISCUSSION

The results presented in this chapter include:

a. Relationship model of time and cost of a simple regression equation/ *Bromillow*.

b. The relationship model of time, cost and volume of the multiple regression equation.

4.1. Simple Regression / Model of Bromillow

From the calculation, the results obtained from *Bromillow* equation for each region that is:

Tabel-2. The results obtained from Bromillow equation for each region

Region	Model $T = K\ C^{B}$	correlation
	$T = k\ c^{b}$	R
Bireun	$T = 24{,}12\ C^{0,14}$	0,30
Pidie	$T = 19{,}01\ C^{0,15}$	0,34
AcehUtara/Lhokseumawe	$T = 12{,}75\ C^{0,26}$	0,91
Aceh Selatan	$T = 24{,}50\ C^{0,13}$	0,72
Aceh Barat	$T = 6{,}68\ C^{0,36}$	0,87
Aceh Timur	$T = 99{,}28\ C^{-0,13}$	0,23
Aceh Tengah	$T = 15{,}68\ C^{0,21}$	0,61
Banda Aceh/Aceh Besar	$T = 53{,}80\ C^{-0,03}$	0,12

Table above shows that the model which has the strongest relationship is a model in Aceh Utara, where T = 12.75 C0, 26 with correlation r = 0, 91 and Aceh Barat at T = 6.68 C0, 36 with r = 0, 87 with strong ties or high. The graph of the model is almost close to perfect as shown in the picture below:

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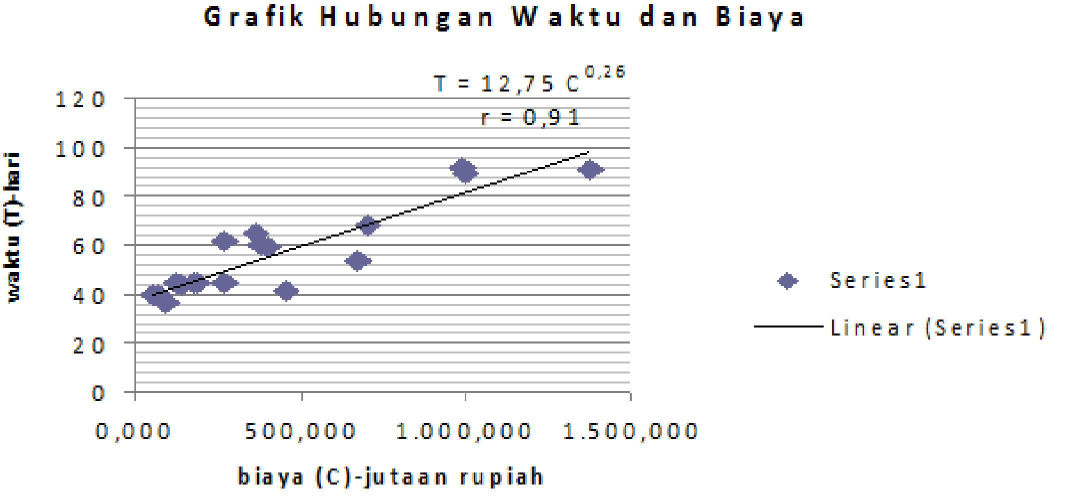

Figure-1. Chart Relationship Between time and cost

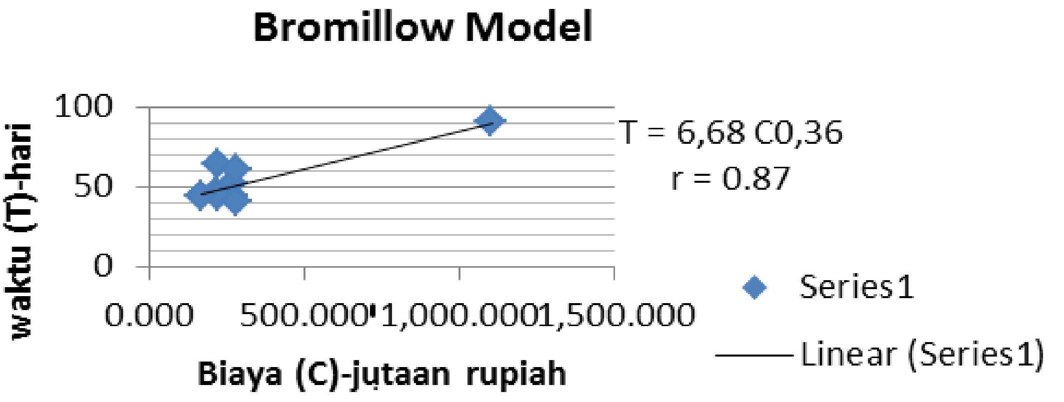

Figure-2. Bromillow Model

From the picture above can be seen that the movement towards a linear regular diagram that indicates two variables: cost and time in Aceh Utara/Lhokseumawe and Aceh Barat have a high relationship (correlation), i e at r = 0.91 with the model T = 12.75 C0, 26 which implies that the cost of one million dollars to produce the time of 12.75 days or 13 days with time sensitivity to the cost of 0.26. and T = 6.68 C0, 36 with r = 0.87 which implies that with cost of one million dollars to produce the time of 6.68 days or 7 days with a sensitivity of time against a fee of 0.36.

While the model used to test the feasibility of the F Test, T Test and Validation levels namely:

F test

List of Analysis of Variance (A nova) Simple Linear Regression For Model T = 12,75 C0,26 in Aceh Utara/Lhokseumawe T = 6,68C036 in Aceh Barat.

Table-3. F test Aceh Utara/Lhokseumawe

Variation	**Dk**	**JK**	**KT**	**$F_{calculation}$**	**F_{table}**
Total	19	57,097	3,005	49,69	4,45
Coefficient (Log K)	1	56,797	56,797		
Regression (B | Log K)	1	0,224	0,224	$F_{calculation} > F_{table}$	
Rest	17	0,077	0,006		

Table-4. F test Aceh Barat

Variation	**Dk**	**JK**	**KT**	**$F_{calculation}$**	**F_{table}**
Total	11	32,128	2,921	15,33	5,12
Coefficient (Log K)	1	32,025	32,025		
Regression (B | Log K)	1	0,066	0,066	$F_{calculation} > F_{table}$	
Rest	9	0,038	0,004		

Tables above explain that each source of variation has a magnitude which is called the degrees of freedom (dK) for the sum total, for the coefficient (log K), the direction of regression (b | log K) and the rest. To determine F in the table obtained dK numerator and dK denominator so that the obtained results F_{table} value distribution table> $F_{calculation}$ to the Aceh Utara and Aceh Barat are based on the null hypothesis that the regression coefficient does not mean rejection or to-2 model obtained by means statistically model can be used.

T test. T test used to determine whether or not the relationship of significant correlation coefficients of time variable (T) and variable costs (C) from equation (2.17) is obtained:

Aceh Utara/ Lhokseumawe.

$t0 = 8,92 > -t\alpha/2 = -2,90$.

Aceh Barat/ Meulaboh

$t0 = 5,42 > -t\alpha/2 = -3,25$.

4.2. Coefficient Determinant (KP/R2)

The coefficient determinant is a number or index that is used to determine the contribution of variable costs (C) of the variation (up / down) the variable time (T), whose value is between 0 to 1 ($0 \le KP \le 1$). To calculate the required value of the coefficient determinant of this correlation coefficient has been calculated previously. By using equation (2.18) the coefficient determinant of (KP) can

By obtaining KP = 82.40%, indicating that the variation (increase / decrease) the implementation of an education building projects due to the cost of the remaining 17.60% is caused by other factors.

By obtaining KP = 76.55%, indicating that the variation (increase / decrease) the implementation of an education building projects due to the cost of the remaining 23.45% is caused by other factor validation.

Table-5. Results Validation of the Model Time Frame Construction with multiple regression analysis in each region:

region	**No. of contract**	**Validation of multiple regression**	
		<15%	>15%
Aceh Utara	19	15	4
Aceh Barat	11	9	2

Based on the above table, can be seen in their respective areas of validation of smaller or larger than 15%, with the level of maximum deviation <50%.

4.3. Time-Cost-Volume Relationship Modell-Multiple Regression.

Tabel-6. Summary of Multiple Regression Results for Each Region.

Region	**Multiple regression Modell** $Y=a+b_1x_1+b_2X_2$	**Correlation R**
Bireun	$Y=50,602-0,007X_1+0,032X_2$	R = 0,33
Pidie	$Y=43,628-0,112X_{1+}\ 0,247X_2$	R = 0,27
A. Utara/Lhokseumawe	$Y=37,729+0.035X_1+0,021X_2$	R = 0,61
Aceh Selatan	$Y=44,703-0,024X_1+0,074X_2$	R = 0,41
Aceh Barat	$Y=44,235+0,115X_1-0,189X_2$	R = 0,44
		Continue

Aceh Timur	$Y=35,330-0,195X_1+ 0,447X_2$	R = 0,50
Aceh Tengah	$Y=42,893+0,114X_1- 0,162X_2$	R = 0,48
Banda Aceh / A Besar	$Y=49,605-0,128X_1-+0,226X_2$	R = 0,04

From the table above are based on models obtained from the calculation of multiple regression analysis and correlation analysis, the equation obtained from each region with a correlation / relationship is different. Seen that the equation in North Aceh / Lhokseumawe have a relationship that is higher than other regression equation that is equal to Y = 37.729 +0.021 X1 X2 +0035 with r = 0.61 that have a sense that these equations have a significant relationship that is located on the interval to (0,4<KK≤0,7).

4.4. Hypothesis Test - F Test

This test is conducted to prove the feasibility of time-cost relationship model and the broad contained in the multiple regression equation is Y = 37.729 +0.021 X1 X2 +0035 using the statistical F distribution and the level of validation. As seen in the following table:

Table-7. F Test

region	Model	r	Uji F (Fcalculation >Ftable)	
			Fpen	Ftabel
Aceh Utara	$Y= 37,729+0.035X_1+0,021X_2$	0,61	4,72	3,63

From the table above shows that the above model of Equality worthy to be recommended because:

- Based on the calculation of correlation coefficient, has a relationship> 0.50.
- Based on the F test, the result F calculation> F table.

4.5. Hypothesis – Validation

The level of accuracy is justified by the condition of maximum error <15% of the facts. The validation results from the model Y = 37.729 ++0035 X2 +0.021 X1 are as follows:

Table-8. Results of Model Validation Time Frame Construction with Multiple Regression Analysis

Region	Total Contract	Multiply Regression Validation	
		<15%	>15%
Aceh Utara/Lhokseumawe	19	16	3

Based on the table above, we can see the level of validation for the model, ie from 19 (Nineteen) contract, there are 16 (sixteen) Contracts which have the validation level <15% and 3 (three) contract that> 15%. Thus equation model Y= 37,729+0.035X1+0,021X2 feasible to use.

5. CONCLUSION AND SUGGESTION

1. Based on the results obtained by model calculation of time and cost relationships in Aceh Utara/Lhokseumawe T = 12.75 C0, 26 which gives the sense that one million dollars takes 12.75 days in Aceh Barat and T = 6.68 C0, 36 takes time 6.68 days.
2. The condition of the relationship of time (T) and cost (C) can be determined using the correlation coefficient for the Aceh Utara district of r = 0.91 with the coefficient determinant of 82.40% due to the cost of the remaining 17.6% by other factors. As for Aceh Barat with r = 0.87 yield determinant coefficient of 76.55% due to the cost and the rest of 23.45 caused by other factors.
3. Further research is needed to develop this research in the future by entering the variables that affect the total time of construction such as labor productivity, the influence of bad weather conditions and others.
4. For further research is expected to collect more data and to review more specific.

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