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Improving measureable external factors influence on construction project duration estimation

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Abstract. The purpose of this study was to determine whether the use of building function variables as dummy variables affected the duration of construction projects, together with identified measureable external factors. Multivariate regression is a technique that estimates a single regression model with more than one outcome variable. When there is more than one predictor variable in a multivariate regression model, the model is a multivariate multiple regression. Goodness of Fit (R^2) of the equation regression analysis used as sensibility benchmarks. Variables are transformed to index number for unit synchronize. If the result is unsatisfied for predicting a project duration, an implementation of dummy variables could be tried if there any improvement of R^2 . The trial on this research, 43 data show that in first stage, five influence factors: Education Index, Technology Absorption Index, Labor Experience Index, New Technology Availability Index, and Innovation Index generate regression equation without full fill the mathematical requirement. At the second stage, by adding dummy variables based on type of building, apartment, office, hotel and other then the three type together with the five external factors, afford a good R^2 .

Keywords: measurable measureable external factors, duration of estimation, factor analysis, multivariate regression analysis, dummy variable.

INTRODUCTION

Some researchers have been tried to identified project successful factors up to now. Lists of variables have been identified shown in some literatures but no general agreement can be made (Chan et al, 2004). Experiences and previous research in the construction industry has shown that variation in production rate values for the same construction item is attributed to the effects of project conditions which are commonly called influence factors. Ng et al. (2001) found that no substantial changes were observed in Bromilow's observations in 1969, but there was a significant increase in the K coefficient value. The relationship is in different geographical regions such as in Australia (Ireland, 1985; Ng et al., 2001), Hong Kong (Chan et al., 1999); United Kingdom (Kaka et al., 1991), Malaysia (Chan, 2001), Nigeria (Ogunsemi et al., 2006), and the United States (Hoffman et al., 2007). Chan et al. (1999) also identified a significant relationship between the duration of construction projects and macro project factors such as floor area, and number of floors. In the study of Ng et al. (2001) conducted a categorization test on several qualitative attributes through variance analysis. The results show that the types of projects substantially have different influences, therefore, this study concludes that there are different groups of



variants in the sample. In Australia, Love et al. (2005) The results of his research suggest construction duration determinants also include linear combinations of dirty floor area and number of floors. Since the success of a construction project could be seen based on the timeliness that has been scheduled, the accuracy of quality standards, and the accuracy of the budgeted costs, a framework concept was developed to identified influence variables on construction project success by Chan et al (2004). Then, Lee et al (2009) used some measureable external factors in his research to predict project duration in a relatively new environment. A similar previous studies showed that some measureable external factors influenced the duration of construction building project in Jakarta. Important factors in project success is measureable external factors, in addition of internal factors, where the measureable external factors are also affect the duration of the construction project and could cause project delays. Many researchers usually used factors analysis method to obtain dominant variables of sets of variables. It is about finding relationships between whole sets of variables, and finding the strength of those relationships. After this step, a dependent variable could be correlated with some independent variables to describe the relationship among them, known as influence independent variables to dependent variable. Regression analysis method is a statistical measurement used that attempts to determine the strength of the relationship between one dependent variable (usually denoted by Y) and a series of other changing variables (known as independent variables). Both methods refered a difference purpose between the method to identification of influencing factors and the method to calculated the magnitude of those influence factors. This caused an inconsistency results of factor analysis method, that the aim is to reduces the number of variables, and regression method which requires level of relationship strength. Since measureable external influence factors fluently composed of three main latent variables, which are: Economics, Resources and Technologies, it is difficult to established strong relationships between one of the three construction project success variables with those reduced measureable external factors (Sousa et al.2014). This paper describes a used indicator variables or dummy variables (Santoso: 2001) model to improved that relationships stated by increasing regression coefficient or goodness of fit (R^2)

METHODOLOGY

In explanatory variables, sometimes there are qualitative data that affect regression calculations (such as education, gender, etc.). Sousa et al. (2014) state that the duration of construction projects not only influences quantitative but also qualitative variables. Variable indicators, commonly referred to as dummy variables, are analyzes that can change qualitative variables into quantitative ones. This variable includes the binary variable. Qualitative factors can be included in regression analysis using variable indicators. The qualitative variables analyzed assume a value of 1 or 0 (Santoso: 2001). Using the binary coding pattern (1.0), this dummy variable is a dichotomous variable. The simple variable indicator regression formula with one independent quantitative variable and one dummy variable is (Kuncoro: 2001) n explanatory variables, sometimes there are qualitative data that affect regression calculations (such as education, gender, etc.). Sousa et al. (2014) state that the duration of construction projects not only influences quantitative but also qualitative variables. Variable indicators, commonly referred to as dummy variables, are analyzes that can change qualitative variables into quantitative ones. This variable includes the binary variable. Qualitative factors can be included in regression analysis using variable indicators. The qualitative variables analyzed assume a value of 1 or 0 (Santoso: 2001). Using the binary coding pattern (1.0), this dummy variable is a dichotomous variable. The simple variable indicator regression formula with one independent quantitative variable and one dummy variable is (Kuncoro: 2001)

$$y = \beta_0 + \delta_0 d + \beta_1 x + u$$

If dummy variable $d = 1$ or $d = 0$, then the formula becomes:

$$\begin{aligned} \text{If } d = 0, \text{ then } y &= \beta_0 + \beta_1 x + u \\ \text{If } d = 1, \text{ then } y &= (\beta_0 + \delta_0) + \beta_1 x + u \end{aligned}$$

Dummy variables are often used in regression and discriminant analysis. Where the coefficient has a direct interpretation. While the use of dummy variables in other multivariate techniques is more limited, especially in analyzes that rely on correlation patterns such as factor analysis because the correlation of binary variables is not well presented by the Pearson correlation coefficient (Hair et al.: 1998).

The steps of the study should be:

1. Identification measureable external influence factors by factor analysis

A number of variables influencing the success of project implementation were identified following a thorough review from several journals (Chan et al 2004). This qualitative selection include measureable external environment to be selected. Analyze dominant measureable variables and collect data measure variables for further regression analysis.

2. Determined the correlation equation of duration and those measureable external factors

Multivariate regression is a technique that estimates a single regression model with more than one outcome variable. When there is more than one predictor variable in a multivariate regression model, the model is a multivariate multiple regression.

3. Calculate regression relationship strength

The strength of relationships stated by goodness of fit (R^2) of the regression equation

$$y = \beta_0 + \beta_1x + u$$

R^2 -squared is a goodness-of-fit measure for linear regression models. This statistic indicates the percentage of the variance in the dependent variable that the independent variables explain collectively. R^2 -squared measures the strength of the relationship between independent variables model and the dependent variable on a convenient 0 – 100% scale.

$R^2 \leq$ dari 0,5 weak correlation

$R^2 >$ dari 0,7 good correlation

4. If $R^2 \leq 0,5$ choose dummy variables

If $R^2 \leq 0,5$, a regression analysis should be added a dummy variable/s, then the equation become:

$$y = \beta_0 + \delta_0d + \beta_1x + u$$

A Dummy variable or Indicator Variable is an artificial variable created to represent an attribute with two or more distinct categories/levels. Dummy variables are created in this situation to 'trick' the regression algorithm into correctly analyzing attribute variables. It usually a latent variable/s

RESULT AND DISCUSSION

First Stage: Relationships without dummy

A study of the factors of measureable external influence on duration, identified several influence variables extracted from several journals. Kog and Loh (2012) identified Critical Success Factors that had an effect on each project actor, namely for architecture, civil work and the M & E division. Dai et al. (2009) was also conducted with a qualitative approach in his research. Identification of latent factors that influence labor productivity is carried out by a factor analysis approach. The Result of the previous study on influence factors on project duration conducted by qualitative method thorough questioner. Distribution of questionnaires and ongoing technical data collection projects carried out in the Jakarta and surrounding areas. Gathering 43 data showed that measureable external factors consist of: Inflation, Material Price Index, GDP, Exchange Rate, Interest Rate, Availability of Labor, Work Experience,

Education Level, Health Level, New Technology Availability, Technology Absorption Rate, Innovation, Inflation. After factor analysis, a set of 5 dominant factors was identified which are: education (X1), technology absorption index (X2), workforce experience (X3), availability of technology (X4), Innovation index (X5) as independent factors and Duration (Y) as dependent variable. The data comes from: BPS (work experience), WEF (education, technology absorption, availability of new technology), and the Global Innovation Index (innovation). Factor analysis and multiple linear regression analysis were conducted to test the relationship of measureable external factors to the duration of estimation of construction projects. In this study, the Goodness of Fit (R^2) of the equation regression analysis used as sensibility benchmarks. Variables are transformed to index number for unit synchronize.

The output of regression analysis in this first stage as seen in table 1

Table 1 *Model Summary*

<i>Model</i>	<i>R</i>	<i>R Square</i>	<i>Adjusted R Square</i>	<i>Std. Error of the Estimate</i>
1	,648 ^a	,420	,341	88,70622462

a. *Predictors:* (Constant), X5, X2, X3, X4, X1

b. *Dependent Variable:* Y

The number of R^2 is 0.420. This means that only 42% of the duration can be explained by variables X1, X2, X3, X4, X5. While the remaining 58% is explained by other causes. This result is unsatisfied for predicting a project duration.

Second Stage: Analysis of Relationships with Dummy Variables

Analysis of relationships with dummy variables can be done if the indicator variable group has met the requirements of multivariate regression analysis. In this study, an analysis was performed using the dummy variable in the second stage. This dummy variables, 4 new independent variables are taken from the types of buildings, namely apartments (X6), offices (X7), hotels (X8), and other buildings (X9). Grouping for dummy variables can be seen in table 2. Because the number of dummy variables used for analysis is (k-1), then other building types are used as base groups (D1, D2, and D3 are set as zero) and are not included in multivariate regression analysis. The coding pattern that will be used in multivariate regression analysis can be seen in table 3.

Table 2 Variable Dummy Grouping Tables

Building Type	Variabel Dummy
Apartment	D1 = 1, selain D1 = 0
Offices	D2 = 1, selain D2 = 0
Hotel	D3 =1, selain D3 = 0
Other Buildings	D4 =1, selain D4 = 0

Table 3 Variable Dummy coding patterns

Coefficient / Dummy Variable	D1	D2	D3
Apartment	1	0	0
offices	0	1	0
Hotel	0	0	1
Other Buildings	0	0	0

After the dummy variable was included in the regression analysis along with the Education Index, Technology Absorption Index, Labor Experience Index, New Technology Availability Index, and Innovation Index as independent variables. The results of multivariate regression analysis using dummy variables in the second stage will be described as follows.

Table 4 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.886 ^a	.785	.727	57.15459942

a. Predictors: (Constant). X9. X8. X7. X2. X6. X5. X3. X4. X1

b. Dependent Variable: Y

The ENTERED VARIABLES by tools shows that there are no variables removed, or in other words the nine independent variables are included in the regression calculation. The R square number is 0.785. this means 78.5% of the duration can be explained by the free variables entered. While the rest (100% - 78.5% = 21.5%) is explained by other reasons. Statistically a R^2 0.785 is a good relationship. The analysis is also shown that the standard error of Estimate is 57,145 (the unit used is the dependent variable, or in this case the duration). Note in the previous descriptive analysis, that the standard deviation of duration is 109,296, which is greater than the Standard Error of Estimate which is only 57,145. Because it is smaller than the standard deviation duration, the regression model is better at acting as a predictor of duration, rather than the average duration itself.

CONCLUSION

The analysis showed that by adding variable/s indicator or dummy variable improved the relationships equation determination by goodness of fit of its relationships. In this study the used of dummy variables increase the determination up to 86.9%. Although R^2 is used as benchmark, another regression model requirement should be noticed also to support the result. In this study, Education Index, Technology Absorption Index, Labor Experience Index, New Technology Availability Index, and Innovation Index together with building type, which are apartment, office, hotel and other then the three type, could be used as influence factors in predicting construction project duration.

However, an obstacles occur in implementation of dummy variables in setting type of the dummy variables which is usually a latent variables and should be so. Another work added in analyze with regression which are the standard mathematical requirement, but by using computer program such like SPSS® and so on.

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