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Prediction Model of Variation Order for Construction Cost and Time in the Residential Projects

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Abstract:
Being a developing country, the construction industry plays a pivotal role in Malaysians development. However, the fast phased industry may have overlooked some of its project management issues namely variation order during the construction stage which effected the project handing over and also increased in the construction cost. The research objective is to develop a prediction model to decrease variation order in residential projects in Malaysia.A total of ten (10) variables were analysed to test their impact on construction cost and time. Two regression models are developed using real data obtained from a project located in the state of Selangor, Malaysia. It was found that there are three independent variables were a significant positive impact on the effects of time and cost in the construction project. The variables are as follows: Scope of work changes by the owner, Changes of building materials and work methods by the owner and Specifications change by the owner. Besides, the prediction model for project cost and time have also validated the results.

Keywords: *Prediction model, Construction project, time, cost.*

I. Introduction

The variation order is unavoidable during the construction stage of the project. Problems related to the variation order also occur in construction projects in Malaysia which resultingdelay inproject handing over and also increased in the construction costs. Variation as stated in the building contract, is referred to changes of works which allow the architect as the contract administrator to instruct variation to the contractor on behalf of the owner during his or her supervision [1]. In terms of construction, [2] stated that variation orders are also referred to as variations. The official documentation for any variation instructions is the document that has been modified from the original contract and forms part of the project document provided by the owner or owner's representatives to the contractor. Increases in construction cost and completion time which cause by variation orders have affected the owner's estimated construction cost as the contractor takes advantage by claiming at a higher rate for the variation work.

Research Problem and objective

Based on the literature review,the major cause of delays in Malaysia construction projects is from variation order [3], [4], [5], [6], [7], [8] and [9]. The main objectives of this research are to develop a prediction model for cost and time in the construction of the residential projects. This model will provide the developer and owner of the residential projects in Malaysia to decrease the numbers of variation order at the early stage of the projects so that positive steps can be taken to reduce delays in residential projects.

II. Research Methodology

In the first stage, the causes and effect of the variation orders identify through a literature review on variation orders were used as the

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reference of case studies.Based on the literature review[10],[11],[12] and [13], 18 causes of the variation ordersaredescribed as follows:Scope of work changes by the owner, Financial problems by the client, Project objectives inadequate,Changes of building materials and work methods,Owner's problems in prompt decision-making,Attitude of the owner on their own opinion,Specifications change by owner,Design change by the consultants, Mistake in design by the consultants, Contradiction between the contract document and the drawing, Technology changes,Value engineering, Coordination among the parties involved was minimal,Complexity of design,Working drawing incomplete, Uncompleted design data provided to the consultant,Poor information onthe building materialsand Ambiguous design details.

Based on the literature review [14], five effects of the variation order are described as follows:Increased project time, Additional in project cost, Impact on project quality,Demolition and rebuilding and delivery delays of construction materials.

Subsequently, the second process of data collection and analysis is a quantitative approach and is carried out with a case study method involving 61 residential projects which were executed by the private sector in the state of Selangor.The data collection from the case studies consist of an interview with the relevant persons such as consultants and owners which involved in the construction residential project and also reviewing archived project documents which to identifying and

analysing the causes and effects of a variation order.The model prediction of construction projects that have been developed will validate to residential construction projects that were not included in this case study to prove that it can be used for the residential projects in the future. The cost and duration of the project of implementation are the same as in the case study.

III. Result and Analysis

From the 18 sources of variation order identified through a literature review was used as a basis in data collection to identify sources of a variation order in the studied. It was found that only 10 causes were related to variation order for residential projects in the state of Selangor. The ten major causes identified are to be used to develop predictive models are as follows (X for dependent variable): (X1):Scope of work changes by the owner, (X2)Changes of building materials and work methods:, (X3):Specifications change by the owner, (X4):Design change by the consultants, (X5):Contradiction between the contract document and the drawing, (X6):Coordination among the parties involved was minimal, (X7): Mistake in design by the consultants, (X8):Working drawing incomplete, (X9):Uncompleted design data provided to the consultantand (X10): Technology changes.

Two (2) main effects of variation order were identified for residential in the state of Selangor from five effects as identified through literature review are to be used to develop predictive models are as follows (Y for independent variable):(Y1):Additional in project cost and (Y2): Increase of project time.

Development of predictive model for construction cost and time

To develop prediction model for construction cost andusing the multiple linear regression method, two main variables have been identified as follows:The dependent variable is the effect of the independent variable. (Y1 and Y2) and the independent variable is the factor that contributes to the dependent variable.(X1 to X10). In this regression study, variables X (causes of variation order) are named as independent variables, while variable Y1 & Y2 (percent of construction cost and time increase) is named as dependent variable.

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In the construction of this regression model the predicted variables that exhibit a very strong positive correlation coefficient with the dependent variables will be included in the equation. The predictor variables selected were X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner). Here are the multiple regression equations that will be used for the construction of project cost and time forecasting models:

i. Predictive model for construction cost-Y1

Predictive model for construction cost Y1= b1X1+

b2X2+…..+ bnXn + a

Description:

Y1 (percentage increase in construction cost) : Dependent variable

X1 (Scope of work changes by the owner) :

X2 (Changes of building materials and work methods) : Independent variables

X3 (Specifications change by the owner) :

a=Constants / regression constants (values Y when X1, X2, ... Xn = 0)

b= Regression coefficient (value of increase or decrease)

The results of the multiple linear regression analysis test for Y1 are shown in Table1.0 and Table 2.0

Table 1.0:Summary model analysis test (Y1)

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.927a	.860	.845	1.08695

Table shows the correlations between the dependent variables X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner) and the YI dependent variable (percentage of construction cost). 927a. The R2 value of .860 indicates that 86.0% of YI-dependent variables (percentage increase in construction costs) were due to changes caused by independent variables X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner).

Table 2.0: Coefficient analysis test (Y1)

	Unstandardized Coefficients		Standardized Coefficients		
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1 (Constant)	5.081	.307		16.569	.000
X1	1.271	.243	.719	5.241	.000
X2	2.506	.721	.907	3.475	.001
X3	-1.949	.560	-.735	-3.480	.001

Table 2.0 shows that there is a significant relationship between dependent variables X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the

owner) and dependent variable YI (percentage increase in project cost) at <.05. Development of predictive model for construction cost is shown as follows:

Predictive model for construction cost Y1= b1X1+b2X2+…..+ bnXn + a

Y1=1.271(Scope of work changes by the owner) + 2.506 (Changes of building materials and work methods)-1.949 (Specifications change by owner) + 5.081 (constant)

ii. Predictive model for construction Time-Y2

Predictive model for construction time Y2= b1X1+ b2X2+…..+ bnXn + a

Description:

Y2 (percentage increase in construction cost) : Dependent variable

X1 (Scope of work changes by the owner) :

X2 (Changes of building materials and work methods) : Independent variables

X3 (Specifications change by the owner) :

a=Constants / regression constants (values Y when X1, X2, ... Xn = 0)

b= Regression coefficient (value of increase or decrease)

The results of the multiple linear regression analysis test for Y2 are shown in Table 3.0 and Table 4.0

Table 3.0:Summary model analysis test (Y2)

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.849a	.721	.707	6.013

Table shows the correlations between the dependent variables X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner) and the Y2 dependent variable (percentage of construction time). 849a. The R2 value of .721 indicates that 71.10% of Y2-dependent variables (percentage increase in construction time) were due to changes caused by independent variables X1 (X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner)

Table 4.0: Coefficient analysis test (Y2)

	Unstandardized Coefficients		Standardized Coefficients		
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1 (Constant)	23.592	1.719		13.725	.000
X1	5.327	1.313	.749	4.057	.000
X2	10.097	3.999	.916	2.524	.014
X3	-9.214	3.147	-.872	-2.928	.005

Table 4.0 shows that there is a significant relationship between dependent variables X1 (Scope of work changes by the owner), X2 (Changes of building materials and work methods) and X3 (Specifications change by the owner) and dependent variable Y2 (percentage increase in project time) at <.05. Development of predictive model for construction time is shown as follows:

Predictive model for construction cost **Y2**= b1X1+b2X2+…..+ bnXn + a

Y2=5.327(Scope of work changes by the owner) + 10.09 (Changes of building materials and work methods)-9.214 (Specifications change by the owner) + 23.592 (constant)

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Validation the prediction model of variation order for construction cost and time in the residential projects

The results of the verification development prediction model of variation order for construction cost and time in the residential project are shown as Table 5.0 and Table 6.0

IV. Conclusion

Two prediction models have been developed as stated in the objective of this study. This model can be used in residential projects in Malaysia, especially for new residential development to solve problems of variation orders.

The models are as follows:

i. Prediction model for project cost

Prediction model for project cost Y1= 1.271(X1-Scope of work changes by the owner) + 2.506 (X2-Changes of building materials and work methods)-1.949 (X3-Specifications change by the owner) + 5.081 (constant)

ii. Prediction model for project time

Prediction model for project time Y2= 5.327 (X1-Scope of work changes by the owner) + 10.097 (X2-Changes of building materials and work methods)- 9.214 (X3-Specifications change by the owner) + 23.592 (constant)

Besides, three independent variables have significant positive effects on variation order. The variables are as follows:Scope of work changes by the owner, Changes of building materials and work methods and Specifications change by the owner. Besides, the prediction model of variation model for construction cost and time in the residential project can also be able to accurately predict construction cost and time in future.

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Table 5.0:The results of virification of the development prediction model for project cost

District	Projects	Increase in project cost% refers to data obtained	Increased project cost% (model development	Differences between original data and model development)
01	Projects 01	13%	11.77%	90.5%
02	Projects 02	12%	11.09%	92.41%
03	Projects 03	10%	8.76%	87.6%

Table 6.0: The results of virification of the development prediction model for project time

District	Projects	Increase in project time% refers to data obtained	Increased project time% (model development	Differences between original data and model development)
01	Projects 01	80%	68.94%	85.80%
02	Projects 02	63%	61.51 %	97.6%
03	Projects 03	55%	61.66 %	97.79%

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