CONTROL OF VARIATION ORDERS IN THE CONSTRUCTION OF RESIDENTIAL PROJECTS IN MALAYSIA

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Abstract

Variation orders are a frequent occurrence in the construction phase of Malaysian building projects. Increased construction time and costs are inevitable when variation orders appear. The aim of the current research is to identify the effectiveness of a "cost and time model" in controlling variation orders during the construction of residential projects in Malaysia. The model was derived from a literature review, which also examined how case studies and data have been utilised to identify the causes and effects of variation orders. These were analysed using multiple linear regression analysis. Three independent variables were identified as significant positive causes, while two dependent variables were determined to be the effects of a variation order. The independent variables signify the owner's changes to the scope of work, construction materials and procedures, as well as their modifications to the specifications. The cost and duration of the project is the dependent variables. The model developed was found to be suitable in practice and the authors propose its application in the early stages of residential construction projects to control the occurrence of variation orders in such projects in Malaysia.

Keywords: Control, Residential Projects, Construction, Time and Cost Time Model

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INTRODUCTION

The construction sector contributes significantly to the Malaysian economy. It also has a sizeable impact on the development of residential projects, infrastructure and various other sectors, such as factory output. Residential construction projects are highly important in ensuring that adequate, high-quality and affordable accommodation is available to meet the housing needs of the population. Residential construction projects must be managed correctly so that they can be completed within the time and cost established and agreed in the construction contract between the developer and the construction contractor. Nevertheless, frequent variation orders during the construction stage have become one of the main problems that may prevent construction projects from being completed within the stipulated time (Ibbs et al., 2001). In addition, this problem indirectly results in higher project costs than had initially been allocated.

Variation orders can be issued for several reasons, and the frequency with which work instructions are changed during the construction phase will likely result in significant changes to the contract, which will impact negatively on all parties involved in the sector. Sun and Meng (2008) stated that a construction industry variation order refers to changes in design, construction work, implementation schedule or project aspects due to the needs of the construction project. Furthermore, any discrepancy in the original project scope or work execution schedule results in a variation order. Mokhtar et al. (2000) stated that while variation orders are undesirable, they are also unavoidable during a construction project. Variation order issues have also arisen in Malaysian construction projects, resulting in project delays and completion failures. According to a study by Chan and Kumaraswamy (1997), the client is the main contributor to variation orders during the construction stage. Several methods have been proposed by researchers to solve the problems of changes that arise during construction and incorrect capital forecasting. Therefore, this paper examines how the variation models developed by researchers can address the problem of construction delays.

LITERATURE

A review of the literature reveals that many researchers have discussed ways to solve the project administration problems that arise during the construction stage, including Al-Mayahi et al. (2018), Ismail et al. (2012) and Tung et al. (2021). However, this paper focuses on the variation order models that are used extensively worldwide to reduce the frequency of construction variation orders.

Generally, only a few models have frequently been referenced. First, Ayman et al. 2008 built a "time and cost model" to reduce project costs and duration due to job changes in the United States The resulting model can be followed by project managers to identify the critical path period of the project schedule and budget in the planning phase. Next, Engy Serag et al. (2010)

developed a model to measure the higher contract prices that result from variation orders during road construction projects in the United States. This model allows the owner to estimate the temporary allocation of money in the event of a variation order. Similarly, to explain the effects of additional time on labour productivity within mechanical and electrical projects in the United States, a multiple linear regression analysis model was produced by Hanna et al. (2005). Meanwhile, Richard et al. (2016) conducted a study on the variation order process model in Nigeria, as well as an extensive and intensive literature review in relation to the existing variation order management model. To reduce the impact of change and manage change from the start of a project to its completion means combining the existing contract provisions with the use of Building Information Modelling (BIM).

In the Malaysian context, only one "time and cost model" has been developed in helping to reduce costs and time arising from order variation during the development of terrace housing projects in Malaysia. This model has been produced as a guideline to address the occurrence of variation orders during the development project of terrace housing projects in Malaysia in particular can be applied during the pre-construction stage of the project to be implemented (Noraziah, 2017). Two models have been developed namely the Cost Prediction Model = b1X1 + b2X2- b3X3 + a = 1.271 (XI for the owner's changes to the scope of work) + 2.506 (X2 for changes in construction materials and procedures) -1.949 (X3 for the owner's modifications to the specifications) + 5.081 (constant) and Time Prediction Model = b1X1+ b2X2-b3X3 + a = 5.327 (XI for the owner's changes to the scope of work) + 10.097 (X2 for changes in construction materials and procedures)- 9.214 (X3 for the owner's modifications to the specifications) + 23.592 (constant). However, to validate the effectiveness of the developed model only the "cost model" will be validated for this study.

RESEARCH METHODOLOGY

This study aims to validate the "cost model" produced by this researcher, as described in the literature review above (Noraziah, 2017). The study involved several phases of model validation, namely:

I.   Model: The concept of understanding the "cost model" produced by
II. the current researcher (Noraziah, 2017)
III. Projects identified as potential case studies: Identification of case studies
IV. related to terrace housing projects in Selangor
V.   Model validation
VI. Findings.

In the first phase, the identified "cost model" was as follows:

Cost Prediction Model (Y1)   =   b1X1+ b2X2- b3X3 + a

                                   =   1.271 (the owner's changes to the scope of work) + 2.506 (changes in construction materials and procedures)- 1.949 (the owner's modifications to the specifications) + 5.081 (constant)

Referring to the model formula above, Y1 is the percentage increase in construction costs (the dependent variable). Meanwhile, X1 refers to the owner's changes to the scope of work, X2 refers to the owner's modifications to the specifications and X3 refers to the owner's modifications to the specifications. X1, X2 and X3 are the independent variables. Meanwhile, the constants / regression constants are referred to by the values of Y, when X1, X2 to Xn are equal to 0 and b is the regression coefficient, which increases or decreases in value.

The second phase involved the identification of projects to select as case studies. In this paper, the selected project was terrace housing built by private developers in the state of Selangor, Malaysia. The terrace housing project selection factors were as follows:

I.   The traditional method was followed
II.   The project cost was within the scope of the developed model
III.   The implementation period was the same as stipulated in the scope of the developed model
IV.   Delays in construction were experienced.

Projects in Selangor were selected because this state experiences the most delays in private sector housing projects. Meanwhile, private development projects were chosen because most housing projects are implemented by the private sector (Alias et al. 2007).

The third phase involved the validation of the "cost model" that had formulated. The model was validated because in the Malaysian context, no "cost and time model" had been developed at the moment. Moreover, no other "cost and time models" had been produced by other researchers. Thus, to identify the effectiveness of the model, a validation session was implemented. Meanwhile, data from terrace housing projects in Selangor was included in the selected model formula.

The final phase was obtaining the results from the validation of the model. Here, the researcher could compare the results from the use of the

developed model compared to the manual "cost and time" calculation. The "cost and time" were obtained manually upon completion of the project. Meanwhile, the model can be used in the early stages of construction. It can reduce the occurrence of work changes that relate directly to cost and time. Once the findings from the use of the model had been obtained, the effectiveness of the model could be identified.

RESULT AND ANALYSIS

Referring to the model validation phase described in the methodology section above, phase one (model selection) and phase two (project identification) have been described. This section describes the third phase (model validation) and the final phase (discovery). It involves two main aspects, (i) cost and (ii) time. However, in this paper, only the cost aspect of the project is validated using the model.

The table 1, below outlines a terrace housing project that was tested to identify the effectiveness of the "model cost".

Table 1: Terrace housing project used for the validation of the "cost model".

Name of housing project	Original project cost (RM)	Increase in project cost (RM)	Project cost increase %
Two-storey terrace house, Shah Alam, Selangor	RM 14,800,000.00	RM 1,924,000.00	13%

Source: Author

Table 1, above shows an example of a terrace housing project in Shah Alam, Selangor that was confirmed by using the model. The table lists the "original project cost", "increase in project cost" and "percentage increase in project cost", compared to the original price. All the data were obtained without using a "cost model" or manual calculation. The data were also obtained after the project had been fully completed.

Validation of the project cost of a two-storey terrace house, Shah Alam, Selangor

Project Cost Validation Calculation
Increased overall project cost (13%) = RM 1,924,000.00

Where;
(100%=57% for X1,X2,X3 & 43% for others)

Therefore,
Increased cost by the client X1, X2, X3 = 57% x RM 1,924,000.00
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ = RM 1,096,680.00
Cost increase by the other parties $\qquad$ = 43% x RM 1,924,000.00
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ = RM 827,320.00

The breakdown of the additional cost to the client of RM 1,096,680.00 is as follows:

Where;
100 % identifies the % for (X1, X2, X3) as follows:
Therefore,
X1 = 60% of RM 1,096,680.00 (to be included in the model)
X2 = 25% of RM 1,096,680.00 (to be included in the model)
X3 = 15% of RM 1,096,680.00 (to be included in the model)

Applying the developed construction project variation order forecast model to the cost of the completed project, the following outcomes emerged:

$Y1 = b_1X_1 + b_2X_2 - b_3X_3 + a$

Whereby;
Y1 $\;$ = 1.271 (the owner's changes to the scope of work) + 2.506 (changes in construction materials and procedures) -1.949 (the owner's modifications to the specifications + 5.081 (constant)
Y1a = 1.271 (0.6) + 2.506 (0.25) - 1.949 (0.15) + 5.081
$\quad$ = 0.763 + 0.627 -0.292 + 5.081=6.179=6.18

Note: b1, b2 and b3 are fixed when used to reduce the increased project cost at an early stage.

While;
Y1b (Percentage increase in cost, etc.) = 43% from 13% (increase in cost to clients and others)
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ = 5.59%
Therefore;
Y1 = Y1a + Y1b
$\quad$ = 6.18 + 5.59
$\quad$ = 11.77%

$\qquad$ Referring to the details of the cost forecast calculation using the "cost model", table 2, below summarises the findings.

Table 2: Validation results of the "cost model" of the construction project.

Name of housing project	Manual: The increase in project cost % refers to the data obtained	Model: % Increase in project cost	Model: % Accuracy of model use
Two-storey terrace house, Shah Alam, Selangor	13%	11.77%	90.5%

Source: Author

Table 2 above shows the percentage difference in project cost increase figures obtained using both the manual and model methods. The grey column in the table shows the findings obtained using the model, while the white column shows the results of the manual calculation (i.e, not using a model). The findings reveal that the model had a high percentage in terms of the cost accuracy forecast, 90.5%. This was due to the percentage increase in project cost using the reduced model, 11.77%, compared to when the manual method was used, giving 13%.

The difference in the percentage increase in project cost can be reduced by 1.23%. Therefore, the project cost reduction for this project was RM 185,000.00 (1.23%).

CONCLUSION

Therefore, it can be concluded that using the "cost model" produced in the study by Noraziah (2017) is effective in helping to reduce the costs that arise due to variation orders during the development of terrace housing projects in Malaysia. The model is presented below:

$$\begin{aligned}
\text{Cost Prediction Model } (Y1) &= b1X1 + b2X2 - b3X3 + a \\
&= 1.271 \text{ (the owner's changes to the scope of work)} \\
&\quad + 2.506 \text{ (changes in construction materials and procedures)} - 1.949 \text{ (the owner's modifications to the specifications)} + 5.081 \text{ (constant)}
\end{aligned}$$

The author proposes that this model should be applied in pre-construction management as guidelines to address the occurrence of variation orders during residential projects in Malaysia. Furthermore, the author proposes to validate the use of the "time" aspect of the "cost and time model". This will be undertaken in a future study of housing projects in Malaysia.

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