ESTIMATING BUDGET VARIABILITY FOR ROAD PROJECTS

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The use of contingency in construction provides a tacit acknowledgement of the perennial problem of cost overruns in the delivery of projects. The effects of these cost overruns are adverse consequences such as projects becoming non-viable or in extreme cases being abandoned. The immediate as well as other stakeholders associated with the project suffer the socio-economic impact of this adverse consequence. To some extent the cost overruns can be deemed as being symptomatic of inadequate planning and budgeting of projects that in turn is a consequence of accuracy of costing data employed for estimating project budgets. The analysis involved in the investigation would help to characterise the scale of escalation on construction projects. The projects would be drawn from the road sub-sector of construction. Understanding the nature and factors that account for the overruns should assist in establishing more accurate project costs. The aim of the study is to explore the nature and scale of project cost overrun in construction to provide information for planning future projects. The study will utilise project data from road schemes to establish the magnitude of the cost overrun.

Keywords: budgets, construction, contingency, projects, roads.

INTRODUCTION

The inclusion and persistence of contingency in budgeting for construction projects provides an undisclosed acknowledgement of the perennial problem of cost overruns in the delivery of projects. Whilst construction has been happy to encourage the practice of budget uncertainty with the use of contingency, there is evidence to suggest that major clients are demanding more cost certainty (McCaffer and Edum-Fotwe, 2005). In one sense, the use of contingency can be deemed as the anticipated budget ceiling for any project. In the past the basis for establishing such contingency had been by rule-of-thumb or sometimes rather arbitrary (McCaffer, 1976). Davey (2000) makes the case that cost overruns often represent symptoms of inadequate planning and budgeting for the projects, which, in turn is a consequence of accuracy of costing data employed for estimating project budgets. Within this paper, the authors explore the nature of budget overrun and present the interim results from an investigation into the scale of construction project cost overrun. The study employed project data from road schemes to establish a generic function for the magnitude of cost overrun. The generic function of cost overrun can be employed to provide information for planning future projects on the most likely levels of contingency to incorporate for improved budget certainty.

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PROBLEM OF COST OVERRUN

Davey (2000) argues that it is not uncommon to find that the final costs of projects grow beyond the proposed estimates at the start. To some degree, construction has come to consider this as inevitable, and so it is all too willing to accept this as the norm. The problem of cost overrun on construction projects is a worldwide phenomenon, and its effects are normally a source of friction between clients and contractors on the issue of price variation (Latham, 1994; Egan, 1998). Some recent projects such as the Scottish Parliament, Wembley Stadium, and Channel Tunnel, all reported very significant cost overruns. The effect of these cost overruns is adverse consequences such as projects becoming non-viable or in extreme cases abandonment. The socio-economic impact of the adverse consequences affects the immediate, as well as, other stakeholders of the project (Arditi and Patel, 1989; Colmer *et al.*, 1999; Kaming *et al.*, 1997). Although the causes of project cost overrun are well known, the methodology used in handling its evaluation, especially with regard to contingency allocation on projects is very inadequate, hence the continues presence of cost overruns on many construction projects (Franks, 1998; Gray and Hughes, 2001; Ibbs, 1984; Morris and Hough, 1989; Burke, 2003; Levy, 2002; Touran, 2003; Tah *et al.*, 1993).

There are two components that contribute to the cost overrun on projects, the accuracy of the estimate, and the control of cost during the execution. Some of the recent researchers on project cost overruns in construction include Mei-Yung *et al.* (2005) who identified stress on estimators as one of the main causes of unrealistic estimates on projects. Chua and Shen (2005) identified late availability of resources and requisite information as the causes of cost overruns on construction projects. Sang-Hoon *et al.* (2005) identified some critical practices which has a great impart on the cost of construction projects Koushki *et al.* (2005) researched over four hundred randomly selected private residential projects in Kuwait and established that contractor-related problems, material related problems, and owners financial constraints were the main causes of cost overruns on the projects. AbouRizk *et al.* (2001) identified thirty-three factors that affect labour productivity and therefore causes cost overruns on construction projects.

The use of contingency is therefore, aimed at addressing the potential cost overrun that occurs on projects (Thwin, 1990; Coleman *et al.*, 2003). While helping to ameliorate the effect of unexpected cost increases, the use of contingency in construction provides a tacit acknowledgement of the perennial problem of cost overruns in the delivery of projects. The adverse socio-economic impacts of the overrun necessitate a better understanding of the nature and factors that account for the overruns so as to assist in establishing more accurate project costs.

NATURE OF COST VARIABILITY

The reason of having a contingency amount as part of the construction contracts is to accommodate the cost due to unexpected events on the project. The amount provided however, depends on the experience of the estimator but not on any scientific basis. The importance of the area of cost overrun necessitates the attention of research since any realistic contingency allocation would serve as the basis for making all financial decisions before and during the progress of works (Abubakar, 1992; Pohl and Mihaljek, 1992; Walker and Hampson, 2003).

The specific focus of the study is therefore to investigate and establish the scale of overrun that occurs on different categories of projects to form the basis of allocation of contingency sums on projects. The analysis involved in the investigation would help to characterise the scale of escalation on construction projects. Understanding the nature and factors that account for the overruns should assist in establishing more accurate project costs. The underlying principle is that there is an optimum level of overrun that can be established from historical data on completed projects, and which can help to establish guidelines for contingency allocation on projects.

DEFINITION OF COST OVERRUN

Generally most actors defined cost overruns on projects as the deviations of actual from estimated cost. In an earlier paper, it was reported that two principal definitions emerge from the literature, the *generic definition* and the *critical activities definition* (Afetornu and Edum-Fotwe, 2005). Within this paper the following definition is adopted.

"*Cost overrun is the additional cost beyond the planned estimated cost of the project*."

This definition encompass both situations where there is a planned contract schedule identify its critical activities and the other case without such schedule.

MODELLING COST OVERRUN

The basis of contingency budgets for construction projects is the extent of cost overrun that is expected to occur during the implementation of the project. The investigation involved establishing the scale of such overrun for completed projects in order to provide a generic function original estimates and the outturn budget for the project. Gilchrist (1984) and Berk (2004) separately support the assertion that mathematical or statistical expressions can be use as a model when some of its properties, its behaviour, are similar to the properties, the behaviour, of the quantities being modelled. The modelling in the study was by regression analysis. Regression analysis is defined by Cook and Weisberg (1999) as the analysis "*to determine as far as possible with the available data how the conditional distribution of the response* ***Y*** *varies across subpopulations determined by the possible values of the predictor* ***X*** *or predictors* $\boldsymbol{X_i}$."

Selection of model
Simple linear regression analysis statistical modelling technique was adopted because of the number of variables involved and the discrete nature of the data. The generic form of the expression for the modelling is represented as follows:

$$Y=\beta_0 + \beta_1 X_1 + \varepsilon \qquad \textbf{Eq 1}$$

where $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$, are the model regression coefficients or parameters, and ε is an error factor or random disturbance.

DATA COLLECTION

The data for the modelling was obtained form forty (40) completed projects spread across ten geographical regions in Ghana. The cost of the projects ranged from the smallest of $12,000.00 to largest of $1,000,000.00. All currency denominations have been converted to the US$.

Modelling Technique

The data was modelled using Statgraphics Plus 5.1. Several functions were explored for fitting the data in order to establish the most efficient. In order to ascertain the model that would give the best R-Squared value, and therefore the best model, different forms of transformation was performed on the original data. The analysis was first performed on the original data, thereafter the variable "**X**" which is the initial cost of the projects in the original data was transformed into three scenarios and analysis performed on each scenario in the study.

RESULTS

Tables 1, 2 and 3 present summary data from the modelling. The model from the analysis is given in the form of the equation:

$$Y = a + bX \qquad \textbf{Eq 2}$$

where "**Y**" variable is the Final Cost, "**X**" variable is the Initial Cost, "**a**" is the constant coefficient or the intercept, and "**b**" is the slope of the line of best fit. Table 1 shows the Standard T results from the estimate of the model parameters. Table 2 presents the Analysis of Variance, and Table 3 shows Correlation Coefficient and other results from the analysis of the original data.

Table 1: Standard T results of the original data

No.	Parameter	Estimate	Error	Statistics	P-Value
1	Intercept	1.89077E8	6.95851E7	2.7172	0.0103
2	Slope	0.999149	0.0455464	21.937	0.000

Table 2: Analysis of variance of the original data

No	Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
1	Model	4.81126E19	1	4.81126E19	481.23	0.000
2	Residual	3.39926E18	34	9.99782E16		
3	Total (Corr.)	5.15118E19	35			

Table 3: Other results of the original data

No.	Parameter	Result
1	Correlation Coefficient	0.966442
2	R-Squared	93.401 percent
3	R-Squared (adjusted for d.f.)	93.2069 percent
4	Standard Error of Estimate	3.16193E8
5	Mean Absolute Value	2.12648E8
6	Durban-Warton Statistic	2.10368 (P=0.3862)
7	Lag 1 residual autocorrelation	-0.0565633

The plot of fitted model produced from the modelling of the original data is given in Figure 1. This gives a strong indication of a systematic relationship between the initial cost and final cost of the project.

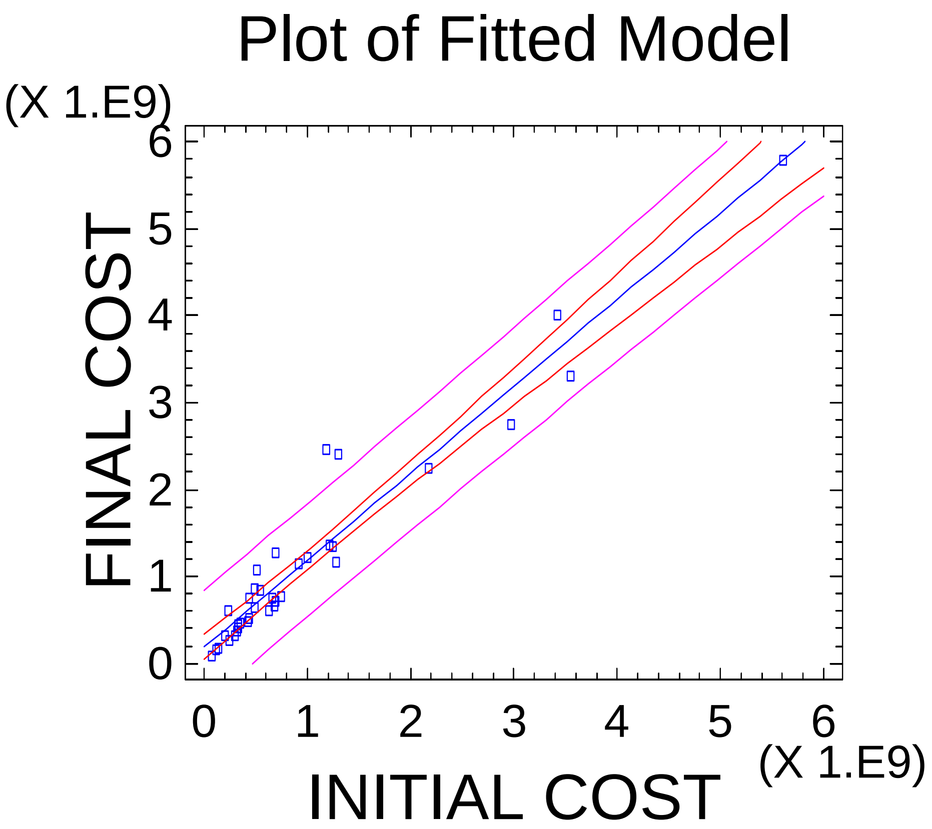

Figure 1: Plot of fitted model of the original data

The results of the analysis gave the equation of the fitting linear model that described the relationship between Final Cost and Initial Cost of the original data as follows:

FINAL COST = 1.89077E8 + 0.999149***INITIAL COST** **Eq 3**

This equation relates to the general equation of linear regression which is given by:

Y = a + b*X

Therefore applying this principle to the equation generated from the original data:

Y = Final Cost,

a = 1.89077E8 which is the constant coefficient,

b = 0.999149 which is the slope, and

X = Initial Cost.

The P-value in the ANOVA table is less than 0.01. This therefore shows that there is a satisfactory significant relationship between Final Cost and Initial Cost at the 99% confidence level. The general nature of the data as a basis of the fitting was good since the R-Squared statistics of 93.401% explains the variability in the Final Cost.

The strength of the relationship between the variables Final Cost and the Initial Cost is measured by the closeness of the correlation coefficient. The correlation coefficient obtained from Table 3 in the analysis was 0.966442. This therefore indicates a relatively strong relationship between the variables Final Cost and Initial Cost.

The prediction limits of new observations depended on the standard deviation of the residuals. From the results in table 3, the standard error of the estimate shows the standard deviation of the residuals to be 3.16193E8. This value therefore could be use to forecast options.

From table 3, the mean absolute error (MAE) is 2.12648E8. This is the average value of the residuals. In order to test the residuals to determine if there were any significant correlation based on the order in which the residuals values occurred in the data file, Durbin-Watson (DW) statistics test was used. The results obtained indicated that the P-value was greater than 0.05. Therefore, there is no indication of serial autocorrelation in the residuals.

Sensitivity Test

The model was tested to see how sensitive the change in initial cost to the final cost from the model equation:

Final Cost = 1.89077E8 + 0.999149*Initial Cost **Eq 4**

The scenarios tested were percentage increase and decrease in the initial cost. The results obtained from both scenarios showed an efficient fit for the model. The information from analysis indicated that the Final Cost is not sensitive to change in Initial Cost between -5% and 5%. The sensitivity of the Final Cost to the Initial Cost increases as the change in the Initial Cost increases outside -5% to 5% boundary.

Minimum Cost of Projects for application of the model

The efficacy of any model resides in the clarity of the range to which it would provide efficient prediction. This involves determining the boundary values for which the application of the model could yield spurious predictions. For the developed model, this critical boundary is the minimum value at which the application of the generic function would yield an efficient prediction. From equation 2, this was derived as the point when the predictor value of X = 0. From equation 4, if the Initial Cost is 0, then

Final Cost = 1.89077E8 + 0.999149* 0

= 1.89077E8, **where E8 = 10^8**

Final Cost = 1.89077 * 10^8

= 189,077,000.00

The above analysis shows that projects that fall below **GHC 189,077,000.00** (USD 21344.18) are considered too small to be captured by the model. It is reasonable to assume that such road construction projects are rather too small for any appreciable overrun to occur during their implementation. Therefore, the model should only be applied for projects above the minimum value of initial cost estimate of GHC 189,077,000.00. It is equally reasonable to assume that there would be an upper limit for the efficient prediction by the model. This aspect of the investigation is currently underway.

CONCLUSION

Cost overruns on construction projects have been accepted by everybody but not much has been done for the minimisation or elimination of the problems associated with cost overruns. The reason was that the true nature and extent of cost overruns was not understood. History can be leant to understand the nature and characteristics to help in deriving a more scientific way of minimising or eliminating the effects of cost overruns on construction projects.

The model in the study would be very useful for obtaining funds for donor funded projects, and for more realistic estimation of project cost. Most donor funded projects are executed on tight budget. Therefore inadequate estimation will result in serious cost overruns on the projects. These effects could be eliminated by the application of the derived model in estimating the expected final cost of projects. The calculated Final Cost therefore becomes the budget for the proposed project. The budget for the project would therefore include the expected cost overruns.

Inflation was identified as the only factor that causes cost overruns on construction projects in developed and developing economy differently. Data for the modelling was obtained from developing economy. Therefore the application of the model is limited to projects in developing economy. The model could however be modified with data from developed economy to enable an appropriate model, suitable for developed economy to be derived.

The model derived from the research would therefore enable project managers and advisers allocate appropriate contingency amounts on construction projects. In this way, cost overruns on construction projects would be eliminated or minimised.

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