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TESTING THE VALUE OF BEST VALUE: EVIDENCE FROM EDUCATIONAL FACILITIES PROJECTS

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Abstract: Contractor selection is one of the most important step in ensuring the success of any construction project. Failing to adequately select the winning contractor may lead to problems in the project delivery phase such as bad quality and delay in the expected project duration; which ultimately results in cost overruns. This paper presents an approach by which a what-if scenario can be analysed in educational facilities projects in the UK; therefore if the client selected the best value contractor for a project whose submitted price is not the lowest price, a what-if scenario was conducted to show how the lowest priced contractor would have fared had he/she been awarded the contract instead. This was done by analysing historic data of projects that have selected the lowest priced contractor. Then correlations were derived between variables; which was then be inputted into a Monte Carlo Simulation to analyse 3 real educational facilities projects that used a best value selection method. Using Monte Carlo Simulation allowed us to see all the possible outcomes of cost, and duration. It was concluded that selecting the best value contractor in educational facilities projects may not be necessary in terms of cost.

Keywords: Educational facilities projects, Contractor selection, Best value contractor, lowest priced contractor, Monte Carlo simulation.

1 INTRODUCTION

Selecting the most appropriate contactor is significant to project success (El-Abassy et al., 2013). Bid price has long been the most dominant criterion for selecting contractors in the UK (Holt et al., 1994). However, due to the different level of complexity and dynamics involved with construction projects, bid price can no longer be the most dominant or the sole criterion for selecting contractors (El-Abassy et al., 2013). Therefore, there are two strategies involved with selecting contractors: one is the lowest priced, the other is called best value or the Most Economically Advantageous Tender (MEAT). If the client chooses to go for the latter strategy, this would involve scoring the contractors' bids on price and quality and ranking them. But what is quality? Which criteria defines quality? There is no set definition for this, each client would their own unique definition of what quality, thus, what best value is to them. Therefore selecting contractor on best value is not as straightforward as awarding the contract to the lowest bidder. This is one of the reasons why industry professionals are finding it difficult to embrace the concept; judging by how the traditional procurement method, which uses the lowest bid award criterion, is still the most used procurement method in the UK (NBS, 2015). There are various models developed in order to help with contractor selection such as simple weighting, Analytical

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Hierarchy Process (AHP), Analytical Network Process (ANP), and multi-utility theory, however only a handful of these models have substantially investigated the link between contractor selection and cost overruns (or project result). For example, Abdelrahman et al. (2008) for one, introduced a concept of best value modelling that was specific to each project; combing two application method: the weighted average method and AHP method. Their tool ranked contractors on best value by using a methodology for quantifying the qualitative effect of subjective factors in the selection process. Cheng and Li (2004) used ANP as an extension for AHP in order to allow access to the interdependent influences specified in the developed model. Kwong et al. (2002) and Bevilacqua and Petroni (2002) used the combination of a scoring system and fuzzy theory for ranking the best value bids. Bendana et al. (2008) also developed a fuzzy logic assessment model both the qualitative and quantitative issues that influence whether or not a contractor is suitable to win the bid for the project. These decision support tools have aided in selecting the best value contractor, however we are still none the wiser as to whether they lead to successful outcomes. The research has conducted a what-if analysis on educational facilities projects in the UK, in order to know whether selecting the best value bid is worth it in educational facilities project. This study is not advocating choosing one strategy over another. Furthermore, this does not imply that a selection strategy is the only factor responsible for delivering a successful project, as there are other factors that leads to overruns (see Flyvbjerg, 2008; Cantarelli et al., 2010).

2 CASE STUDY

2.1 Initial Analysis

The Building Cost Information Service of RICS (BCIS) database was used to conduct this study. A total of 120 Educational facilities projects, all of which was awarded to the lowest bidder, were analysed. Each project showed:

- Details of the contract awarded (tender bids received from all the contractors that bided for the project; companies shall remain anonymous)
- Selection criteria; (lowest tender accepted)
- The wining contractor: the eventual tender accepted
- Project outcome cost: initial tender cost, final cost, the expected duration, and actual duration.

The BCIS database states the reasons for overruns, for example there was a project that overran by £20,000, and this was due to the client making design changes. These sort of projects were not used for this study; all 120 projects where cases whereby the contractor solely impacted the outcome of the project, at least form the reasons given. The study was to see whether awarding the project to the lowest tender will result in a higher outcome cost, and duration than awarding to the best value tender.

From this dataset (120 project cases), correlations were derived between three variables using Excel (see Table 1 for correlation):

- Bid price (BP, which in this case, is always the lowest tender)
- The difference between the final cost of the project and the tender accepted price (Diff)
- Delay

Table 1: Correlation between BP, Diff, and Delay

	BP	Diff	Delay
BP	1	0.570946	-0.02224
Diff	0.570946	1	0.021491
Delay	-0.02224	0.021491	1

2.2 Model Development

Cost and time are two of the most important objectives which can easily be quantified. Quality on the other hand is subjective, thus making it more difficult to quantify. However, there are concepts that have been introduced to try and quantify it (see Juran, 1951; Crosby, 1979; and Waje and Patil, 2012). This study however, focuses on how the strategy affects the outcome cost and duration. As there is no universal way of judging quality, it was not used as a parameter for this experiment.

The developed simulation model for assessing how the lowest priced contractor would fare if he/she is awarded the contract simply simulated the correlation given in Table 1. This model provided the frequency distribution of all the possible final costs that a project could incur. The model was developed using the MATLAB R2014b software; this is a predominantly mathematical modelling environment that performs the Monte Carlo simulation approach effectively and efficiently.

The strength of the tendency is measured by the correlation between low tenders and the difference between the final cost of the project and the tender bid (Diff). In simple terms this can be expressed as the correlation coefficient, ρ. In order to generate a set of correlated random numbers a simple equation will be used

$$\mathbf{x} = \mathbf{A\eta}\ (1)$$

Where x is a vector of n correlated random numbers of mean zero and unit standard deviation , which will be rescaled later to produce quality, overrun, tender price later. A is an nxn matrix of coefficients and η a vector of n independent random numbers to some distribution with zero mean and standard deviation of one.

$$\begin{bmatrix} \mathbf{x_1} \\ \mathbf{x_2} \\ \mathbf{x_3} \\ \cdots \\ \mathbf{x_n} \end{bmatrix} = \begin{bmatrix} \mathbf{a_{1,1}} & \mathbf{a_{1,2}} & \mathbf{a_{1,3}} & \cdots & \mathbf{a_{1,n}} \\ \mathbf{a_{2,1}} & \mathbf{a_{2,2}} & \mathbf{a_{2,3}} & \cdots & \mathbf{a_{2,n}} \\ \mathbf{a_{3,1}} & \mathbf{a_{3,2}} & \mathbf{a_{3,3}} & \cdots & \mathbf{a_{3,n}} \\ \cdots & \cdots & \cdots & \cdots & \mathbf{a_{1,1}} \\ \mathbf{a_{n,1}} & \mathbf{a_{n,2}} & \mathbf{a_{n,3}} & \cdots & \mathbf{a_{n,n}} \end{bmatrix} \begin{bmatrix} \boldsymbol{\eta_1} \\ \boldsymbol{\eta_2} \\ \boldsymbol{\eta_3} \\ \cdots \\ \boldsymbol{\eta_n} \end{bmatrix}$$

A can be evaluated by taking moment and mathematical expectations as proposed by Matalas (1967).

Post multiply both sides of equation 1 by $\mathbf{x^t}$ gives

$$\mathbf{xx^t} = \mathbf{A\eta}(\mathbf{A\eta})^{\mathbf{t}}$$

$$\mathbf{xx^t} = \mathbf{A\eta\eta^tA^t}\ (2)$$

If we take the expected values of these then the expected value of $\mathrm{xx^t}$ $\mathrm{E(xx^t)}$ is the correlation matrix between all of the values, M

$$\mathbf{M} = \begin{bmatrix} \mathbf{1} & \boldsymbol{\rho_{1,2}} & \cdots & \boldsymbol{\rho_{1,n}} \\ \boldsymbol{\rho_{2,1}} & \mathbf{1} & \cdots & \boldsymbol{\rho_{2,n}} \\ \cdots & \cdots & \cdots & \cdots \\ \boldsymbol{\rho_{n,1}} & \boldsymbol{\rho_{n,2}} & \cdots & \mathbf{1} \end{bmatrix}$$

Since the η values are independent of one another their expected cross correlations are zero with the diagonal elements the variances of the elements, 1. This is the identity matrix I.

Any matrix pre or post multiplied by the identity matrix is unaltered therefore the expected values give.

$$\mathbf{M} = \mathbf{AA^t} \ (3)$$

Any matrix multiplied by its own transpose will give a symmetrical matrix and the correlation matrix is bound to be symmetrical. This means that there are effectively only $n(n+1)/2$ independent variables in A. There are numerous ways to evaluate these independent variables, for example by assuming A is upper triangular or using the eigenvectors and eigenvalues of M. Since Matlab has a function to do this this will be the function used.

In this simulation experiment the correlation from Table 1 are used to derive random numbers which are then inputted into the model. This then generates frequency distribution of the tender bids accepted, which is instructed to always be the lowest price, a Diff cost, and Delay time. Subsequently these distributions are then used to calculate the frequency distributions of Total cost and Actual Duration of the projects.

$$\textbf{Total cost} = \textbf{BP} + \textbf{Diff}\ (\textbf{4})$$

$$\textbf{Actual Duration} = \textbf{Client}'\textbf{sexpected duration} + \textbf{Delay}\ (\textbf{5})$$

2.2.1 Simulation

Remember that the study aims to show how the lowest tender would have fared on a project that has already been awarded to the best value tender. Therefore the first experiment is to test the model on three real educational facilities projects to see whether it was able to predict the frequency distribution of all the possible outcomes. If the actual project outcome is within the minimum and the maximum values, this validates the model. The Tables below show the tender bids of the 3 projects awarded to the lowest tender, their actual outcomes, and the simulation results.

Table 2: Lowest tender projects

	A	B	C	D	E	F	Exp.(days)
1	£737,586	£791,162	£793,524	£805,139	£831,777	£1,069,635	134
2	£1,802,892	£1,835,219	£1,894,698	£1,918,792	£1,942,107		225
3	£607,107	£610,510	£611,573	£620,263	£622,677	£649,873	225

Table 3: Outcomes P1, P2 and P3

	Minimum	Maximum	Mean	Actual
FC	£766,370	£816,820	£790,270	£784,667

Time	97	206	139	157
Diff	£28,784	£79,234	£52,684	£47,081
FC	£1,797,600	£1,849,900	£1,824,700	£1,814,892
Time	167	291	230	225
Diff	-£5,292	£47,008	£21,808	£12,000
FC	£584,060	£640,740	£611,670	£638,271
Time	161	297	230	225
Diff	-£23,047	£33,633	£4,563	£31,164

Therefore, as the actual outcomes were able to fall within the envelope of the predicted outcomes from the model. The model could now be tested in 3 real educational facilities projects that selected the best value tender. In this case, the actual outcomes would be that of the best value tender. In Figure 5, Contractor C was selected in Project 4 and 5, and Contractor B was selected in Project 6.

Table 4: Best value tender projects

	A	B	C	D	E	F	Exp.(days)
4	£4,299,664	£4,343,931	£4,371,596	£4,447,081	£4,724,370	£5,017,168	292
5	£2,096,388	£2,108,776	£2,123,918	£2,206,340	£2,278,743		134
6	£261,778	£313,826	£328,959	£376,187			89

Table 5: Outcomes P4, P5, P6

	Minimum	Maximum	Mean	Actual	Actual-Max	Actual-Mean
FC	£4,291,400	£4,328,600	£4,309,000	£4,371,596	+£42,996	+£62,596
Time	225	364	297	292	+72 days	+5 days
Diff	-£8,254.40	-£28,947	£9,370	£0.00		
FC	£2,069,300	£2,120,100	£2,095,600	£2,123,918	+£3,818	+£28,318
Time	73	205	139	134	+71 days	+5 days
Diff	£2,511.70	£23,712	£28,839	£0.00		
FC	£288,980	£343,820	£317,660	£343,200	-£620	+£25,540
Time	51	155	94	89	+66 days	+5 days
Diff	£27,202	£82,043	£55,884	£29,374		

2.2.2 Sensitivity Analysis

A sensitivity analysis was done to see how many times the lowest bid would still be the best overall bid if the correlations between the Bid Price (lowest tender) and the Diff in Table 1 changed using Project 1. Interestingly, it did not entirely affect the outcomes;

the lowest bid still turned out to be the best bid majority of the time (see Figure 1). The sensitivity analysis was conducted on Project 1.

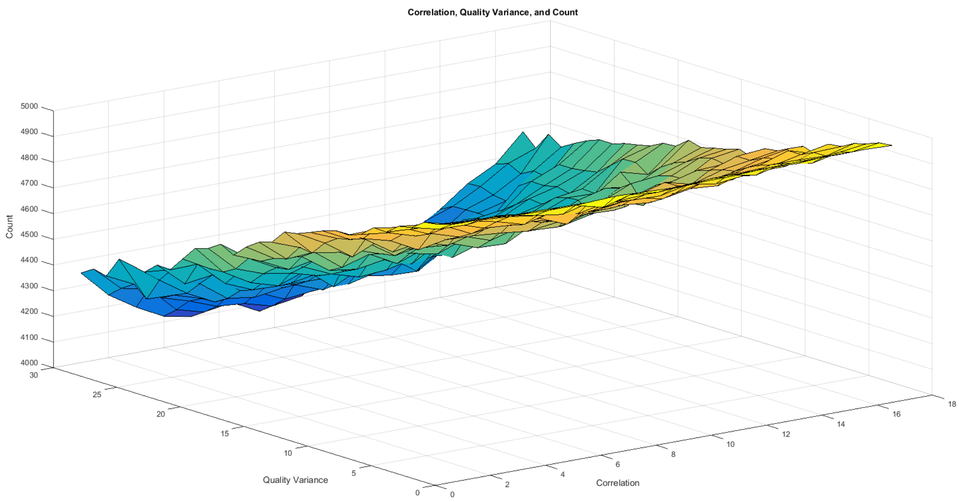

Figure 1: Correlation, Diff, and Count

- The X-axis is the correlations that ranges from -0.8 to 0.8 (removing the extremities of -+1 and 0.9), with a step of 0.1; this is then given a range from 0 to 17.
- The Y-axis is the standard deviation of Diff that ranges from £1000 to £30,000; this is then given a range from 0 to 30.
- The Z-axis counts the number of times that the lowest tender did turn out as the best overall bid; in other words if the amount of time that the lowest bidder's outcome cost, turns out to still be lower than the next highest bid.
- The model was given 5000 realisations.

The result of this analysis showed that when the correlation is highly negative, given the range of Diff, there is still a high chance that the lowest tender is the best bid; at least 82% of the time. The more positive the correlation becomes, given the range of Diff, the higher the chance that the lowest tender is the best bid. This sort of result is impossible to analyse by only altering the correlation; which is why the standard deviation was also altered to show the surface of the curve. The result supports Project 1 model results, given the correlation used for the model, which had a high chance of the lowest bidder turning out to be the best bid in terms of outcome cost. The reason for this is possibly due to the fact that the standard deviation of the tender prices in Project A was over £100,000; the lowest bid for example was £737,586, while the highest bid was £1,069,635. This means that the overrun cost of going with the lowest bid should be over £300,000 for the lowest bid not to be the best bid, if we are just comparing the two. Therefore further analyses is required which involves reducing the standard deviation of the tender price and increasing the variance of Diff to see how this would affect the results.

3 DISCUSSION

In Project 6, the best value tender overran by almost £30,000 but still manages to deliver the project in 89 working days, which was the client's expected duration. Interestingly, the maximum cost the lowest tender would have achieved is just £620 over the actual cost of the project, though the risk of it happening was slight. This possibly suggests that a scope was added to the project, or an unforeseen situation developed that affected the cost. Apart from that, the result showed that there was a higher chance of the lowest tender completing the project at a lesser cost to the best value tender; despite the fact it incurs a cost overrun. This is also the case with Project 4 and 5.

However, the notion of selecting contractors on best value tenders does not only depend on cost. Though best value will have a different meaning to different people, a client's best value expectation may be quicker duration time. In terms of that, the results show that despite the fact that there is a high chance that the lowest tender will complete the project at a lesser cost than the best value tender, it may come at the expense of it exceeding at the client's expected duration. There is a risk that the project would take longer to complete if given to the lowest tender, therefore, it comes down to how risk averse the client is. Would the client be willing go with the lowest tender but risk a longer duration time? One can argue that these results are based on the fact that in educational facilities projects, requirements are usually familiar, and building parameters are not very complex. However, the strength of this study is that it is also able to show when projects may not turn out as planned.

4 CONCLUSIONS

This study looked at how the lowest tender would have fared in projects that awarded contracts to the best value tender had he/she been awarded the contract instead. Correlations were derived from 120 educational facilities projects in the UK, this was inputted into the model that was first tested on 3 real projects in the same sector that chose the lowest tender. This was in order to see whether the actual outcomes of these projects would fall within the envelope of all the possible outcomes that was predicted in the model. Then, the same model was then tested in 3 real educational facilities projects in the UK that picked the best value tender. All 120 projects were cases where the contractor was mainly responsible for the project outcomes, for example they were no design changes reported or any other reasons from the clients' side that affected outcomes. The results showed that though it is likely that the lowest tender would deliver at a lesser cost than the best value tender, it will likely overrun both in cost and duration. Therefore it boils down to how risk averse the client is in taking the chance, and what best value is to him/her. The sensitivity analyses conducted for this study involved changing the correlations, this had little effect to the outcomes. Further analyses that include changing the correlation and the standard deviation would have to be undertaken to see how it affects outcomes.

Furthermore, the results shown in this study is limited to educational facilities projects. Thus, the study should be done in other sectors, and even with individual clients, to see how the lowest and best value tender fare. Perhaps, the fact that educational facilities projects are less likely to change in terms of scope would mean that the lowest tender would generally fare well. Also, it is important to note that clients now utilise a preferred contractors' list, therefore the assumption is that every contractor that makes the list is capable of delivering. This may be entirely different in other sectors in the construction industry, therefore further study is required. Finally, the use of the BCIS database may possibly bring in a certain level of bias. It is likely that companies are likely to report projects which went considerably well; thus results should be interpreted with a bit of caution. However, this dataset was validated on real life projects in which the outcomes was known.

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