The accuracy of preliminary cost estimates in Public Works Department (PWD) of Peninsular Malaysia

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Abstract

This paper presents the accuracy of preliminary cost estimates prepared by Public Works Department (PWD), which is the largest public construction management in Malaysia. It attempts to understand the Quantity Surveyors’ (QS) estimation accuracy in relation to public projects. This study analyses 83 projects of estimates and tender bids. The analysis includes three (3) estimating targets i.e. lowest bid, accepted bid and mean of the bids. To broaden the study, 344 QS involved in the procurement answered the questionnaires. Linear multiple regression analysis on project characteristics shows that project size, number of bidders, location and type of schools affect the bias. Contract period affects the consistency. The use of mean of the bids is the best-fit target to explain the bias in terms of adjusted R². The accuracy may improve if sufficient design information is available, proper cost planning and improving the application of historical cost data. As an alternative, the phenomenon of overestimation is resulted from government directive instruction, which could challenge the rational of accurate estimate.

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1. Introduction

Preliminary Cost Estimate determines the viability of public projects. It serves as a budgetary control during initial design stage. The government often considers the estimate as cost limit of projects. The estimate is based on size and functional unit of buildings using cost indicators of similar projects (Morton and Jaggar, 1995). It depends on information gathered at early design stage. The estimate is prepared according to desired quality, in accepted time and within budget (Karlsen and Lereim, 2005). The stakeholders of a project need to identify the possible cost before making monetary investment. The actual cost is known after the project is completed but the investment decisions need to be made before the construction begins.

Public Works Department (PWD) of Malaysia is the largest public construction management organization, which supervises and provides in-house solutions for public agencies in Malaysia (Abdul-Aziz and Ali, 2004). The early cost advice of public funded projects is essential because budget constraint limit the government capacity to spend (Morton and Jaggar, 1995). If the estimate is too low, the proposed project design could be abandoned, and it may also lead to a lawsuit (Ashworth, 2010). Overestimation leads to a lesser fund available to other projects and underestimation results in difficulty to the contract (Odusami and Onukwube, 2008). To overcome these problems, Public Works Department could take...
two (2) possible actions, that is design amendment, or requisition of additional budget (Public Works Department, 2010). Even so, these recommendations may not resolve the inaccurate estimation. As usual, QS overestimated the estimate (Aibinu and Pasco, 2008; Ashworth and Skitmore, 1982; Cheung et al., 2008; Skitmore and Drew, 2003; Skitmore and Picken, 2000). Most of the time, clients and QS are more likely to accept overestimation rather than underestimation (Cheung et al., 2008). They are generally contented with overestimation because it brings more benefits with less risk than underestimation. A study made in Singapore by Ling and Boo (2001) shows the expected accuracy assured by QS are way off from the true values when compared to analyzed samples.

According to official records, 57.39% of projects managed by PWD were public school projects and the department is still using pre-design drawings for public facilities e.g. school, hospital, government office and public housing scheme (Public Works Department, 2009a). The rapid development in Malaysian economy increases the demand for public facilities mentioned. To overcome this overwhelmed demand, the pre-design drawings have been introduced by the PWD to speed-up the construction and it reduces the cost through the use of standardized construction process and components (Norwina, 2006). However, according to official statement from the PWD itself, the reliability of QS department in performing estimation was in doubt (Public Works Department, 2004, 2005). This jeopardizes the merits of standard designs, as it should be able to help the government in terms of prudent cost management advice by the QS. Construction Industry Research and Information Association (CIRIA) ascertain that standard design projects need to be managed effectively using optimized solutions to overcome some cost irregularities because the construction industry is still inherited with inefficiencies, even standardization comes into place (Gibb, 2001). Evidences show that economies of scale in the construction industry are very difficult to achieve because they involve high labor intensity and few standardized products (Hillebrandt, 2000; Valence, 2011). Therefore, continuous improvement for pre-design projects especially in-cost estimation leads to more value for money for the government. In addition, this paper offers interesting view on disutility function, which might offer an alternative answer in relation to the phenomena of overestimation of public projects. It might reject the rationale of accurate estimate (symmetrically near to zero mean). This might help future research on the improvement of cost estimate.

2. Literature review

2.1. Review of Public Works Department estimating procedure

The PWD uses standard forms for cost plan. The estimate is tabulated according to the elemental costs breakdown. The cost estimate is calculated using historical and current prices (Public Works Department, 1992). Currently, there are only two (2) types of estimating methods used by the PWD: single rate method and estimated quantities (Public Works Department, 2010). The estimate is prepared using preliminary design plan. The QS officers used average cost data (cost/m²GFA) of suitable building and adjust it according to tender price index and locality factor. Then, the cost is multiplied by m²GFA of the area. The cost for Preliminaries, Internal Building Specialist Works, External Works and Professional Fees are calculated according to average percentage collected from previous projects. The cost data is obtained from the previous accepted tenders (Public Works Department, 2009b). The current estimating policy in the PWD remains unchanged, as the new guideline introduced in 2010 does not provide any other methods or amendments in relation to the estimating procedures (Public Works Department, 2010). Most QS are not willing to change into new ways of preparing the cost estimate (Fortune and Cox, 2005; Raftery, 1991). As for now, it is foreseeable that the improvement to current estimating process and procedure are the way forward to improve the estimating accuracy.

2.2. Estimating accuracy

Accurate means lack of error. It comprises two (2) aspects in terms of “bias” and “consistency” (Ashworth and Skitmore, 1982; Morrison, 1984; Skitmore, 1991). Bias is concerned with the average differences between estimate and tender price according toarithmeticalmean of percentage error (Skitmore, 1991). The greater the average differences, the more bias the estimate. Consistency is the degree of variation around the average which means it measures how often the accuracy can be relied on (Ashworth and Skitmore, 1982). In theory, accurate estimation is the one closer to the tender price. However, this concept might raise some issues because overestimation could be rewarding due to persistent trend of overestimation in almost all QS practices (Cheung et al., 2008; Skitmore and Cheung, 2007).

2.3. Target measures of forecast quality

The purpose of estimating is to make a prediction. There must be a reference point to measure the estimating performance. Some agree that the lowest tender price as the estimating target (Gunner and Skitmore, 1999a; Morrison, 1984; Skitmore, 1991). The quality of the estimating models depends on how accurate the model predicts the bid value, which is usually an unknown value, but due to the nature of competition in bidding, the lowest bid is usually the target for most contracts. However, to some extent, using the lowest bid may not represent the value for money as it could be a suicidal low bid price offered by a bidder (Skitmore and Lo, 2002). This unrealistic low bid is a result of some bidders’ desire to win the contract at any cost (Herdman and Ellis, 2006; Murdoch and Hughes, 2007; Runeson, 2000). The loss from low bid strategy could be recouped through project management during construction. The second lowest bid, in fact, might be better economically than the lowest bid (Low and Skitmore, 2006). This shows that the lowest price cannot guarantee the best value. To resolve this problem, McCaffier (1976) suggests the use of mean of the bids instead. His argument is that the mean has less interference variable (suicidal low bids), and more likely to be more accurate. However, Raftery (1991) points out that the use of mean of the bids as the target could be affected by uncompetitive prices (high-priced bids) and this affects the average value as it
will become one-sided to uncompetitive price. Some used accepted tender bids to measure the estimating bias because it is the price accepted by clients (Aibinu and Pasco, 2008; Gunner and Skitmore, 1999a; Raftery, 1991). Skitmore claimed that the drawback of using accepted bid is that it may have been influenced by the QS and therefore it is interdependent to some extent with the estimate (personal communication, December 17, 2010).

Some others used the final completed cost as the target because it provides the total commitment cost to the client (AbouRizk et al., 2002; Shane et al., 2009). However, Skitmore (2002) and Runeson (2000) explain that there are some problems of using final completed cost. The problem is that the data is not readily available and when it is available, it is not well recorded. They point out, due to long delay between the estimate and final cost, significant changes of design and price fluctuation occurs during construction. In addition, the contractor is reluctant to give the true cost that shows the project’s actual expenses (Skitmore, 1988). It becomes a norm for business practices not to expose information to others. It shows that there are many views pertaining estimating targets. In PWD of Malaysia, the lowest tender price is not the main criteria in the selection of a bidder to be awarded the contract. The PWD uses “average bid method” as against to “lowest bid method” (Faridah Halil, 2007; Public Works Department, 2004, 2005). This shows that the use of mean of the bids is more appropriate.

Average bid method allows reasonable profit to contractors (Ioannou and Leu, 1993). The contract prices are high-priced but it could decrease risks of delay, substandard quality and disputes. The PWD states one of the reasons of using this method is because the QS estimates are more prone to errors and it may discourage insiders from giving the estimated figure to bidders (Public Works Department, 2004, 2005; Sharinah Hamid, 2008). This reduces the risk of inaccurate estimation being used as a benchmark. Countries like Italy and Taiwan used this tender price assessment to reduce unrealistic low bids (Ioannou and Leu, 1993; Kumaraswamy and Walker, 1999). The mean is calculated from the total bidders’ prices which include the estimate prepared by PWD QS officers to create the lowest acceptable market price or “cut-off price”. This is the main criteria of price selection. The prices offered must not be lower than the price determined by the method. Those bidders who priced the tender lower than the amount calculated could also win the contract award if they have good record of accomplishment and sound financial standing. The prices should not be lower than 20% of the mean of builder’s work price (Public Works Department, 2004, 2005).

However, not all tender evaluations used the average bid method e.g. selective tender, design and build tender or open tender that required expertise (Public Works Department, 2004, 2005). In general, the procurement of standard design projects use open tendering process because the design is uncomplicated and more contractors are willing to bid. In open tender, the PWD tender board could reject “the lowest acceptable market price” if the bidder is in bad financial condition or bad record of accomplishment. Generally, projects that require expertise would go to pre-qualification process before the bidders can bid the tender. The pre-qualification process looks into financial and expertise record. This limits the number of tenders entering the bid.

2.4. Factors which affect the accuracy of the estimate

QS’s pricing activities affect the quality of the estimate in relation to many factors. This behavior causes systematic biases (Raftery, 1995). This includes heuristics in decision-making, personal biases and reporting biases. This happens because of imprecise process and subjective decision during estimation (Ashworth and Skitmore, 1982). Factors contribute to the estimation bias could be influenced by more causes and inter-correlation between variables may be presented. It could be a result from the effect of confounding variables that camouflage the important variable (Gunner and Skitmore, 1999b). Skitmore (1991) established that the project characteristics determine the QS estimating performance. These factors are building function, contract type, contract condition, contract sum, contract period, number of bidders, economic condition, procurement basis, project sector and location. Subsequently, price intensity (cost/m²) was added to the existing variables. In common practice, QS takes the price per meter square floor of comparable building as a starting point then adjusts it to the anticipated value (Gunner and Skitmore, 1999b; Skitmore and Drew, 2003). Therefore, in this theory, judgmental bias by QS will be the significant deciding factor when adjustment or pooling cost data (cost/m2) is made. The following Table 1 is the summary of empirical evidences on project characteristics which affects quality of the estimate.

QS’s biases lead to overestimation in many countries when comparing the differences between estimate and bid (Skitmore et al., 1990). This brings to an opinion that QS simply add on the ‘raw’ estimate with the amount they felt suitable (Cheung et al., 2008). QS aims to be on the safe side when preparing the estimate. QS could predict his estimate will be too high or too low because of his years of experience in preparing cost estimates (Skitmore and Cheung, 2007). Some said no QS wants to prepare underestimated estimate because they want to avoid unpleasant surprise to the clients if his estimate is the lowest (Magnussen and Olsson, 2006). QS may be at risk of being sued by his client or his project could be abandoned (Chappell et al., 2001). A bidder who knows a fair amount of information about a project decreases their price margin compare to bidders who were given partial information (Soo and Oo, 2007). QS is suspected to increase his pricing if little information is obtained. A PhD thesis by Yeung (2009) found that projects with less variance in the project specification using the same target group e.g. residential, car-park, social community, hotel, residential and school buildings provide an acceptable level of accuracy. However, the problem regarding projects with large variances in the project specification e.g. hospital, university and commercial center buildings is that there are only few cost references available. The variance means the variations in project specification and construction price range. Inaccurate estimate could also happen because bidders may deliberately be bias during estimation rather than due to random effect (Flyvbjerg, 2009; Flyvbjerg et al., 2002; Magnussen and Olsson, 2006). They show that underestimation or cost overrun occurred when the estimate is lower than the value of final cost. They explain that a bid price by a project promoter is more likely to be underestimated during bidding because public clients prefer inexpensive option and it happens because of political pressure to secure funding. In
addition, promoters and public officials overestimate the benefits of the project. However, according to Shane et al. (2009), contractors’ bias estimate is a tendency to be overoptimistic about the significance of cost factors which results in the bid to be underestimated. There are many breakthroughs in alternative estimating method and quality management system. Most of the time, QS do not change their estimating policy in reaction to previous estimates because they are not aware of the error trend they developed during estimation (Morrison, 1984). This leads to the estimate not improving over time (Aibinu and Pasco, 2008). The following are the research questions based on the research problems:

a) How accurate are the preliminary cost estimates using standard design plans prepared by PWD?

b) What is the best estimating target to explain the bias in the estimate?

c) To what extent could the project characteristics significantly affect the accuracy of preliminary cost estimates prepared by the PWD?

d) Why biases happen in PWD procurement and how to overcome this problem?

3. Research method

This research explores the significant relationship between biases of the estimate (observed variables) and project characteristics (predictor variables). In addition, it compares which estimating target i.e. lowest bid, accepted tender and mean of the bids to find the best-fit linear model to explain the estimating bias. Therefore, this research makes comparison using the same set of data. QS in PWD priced the estimate using elemental cost order. These costs determine the total cost of a project. The only way to examine cost distribution in the estimate is to compare it with tenders’ elemental prices. A large variance in elemental cost is expected to influence the total accuracy. It was assumed the unbalanced bids by the bidders might not affect the analysis because the bid prices transferred to contract bills of quantities are rationalized to ensure the prices are acceptable. It means that after the signing of the contract between the accepted tender and the government, it is the duty of the QS officers to make sure the tender do not price high rate on some items and low rate on the others. The effect of unbalanced bid is that the comparison between elemental prices of the samples collected may not reasonably explain the true distribution of elemental prices.

3.1. Data collection

The data from 83 projects were collected randomly from CKUB, PWD files. The projects were designed and estimated by PWD. The total approved estimates were RM 280,740,476.45. The total approved contract prices were RM 250,539,830.40. All these projects are located in the west coast of Peninsular Malaysia. These are the state of Kedah, Perak, Negeri Sembilan (N9), Malacca and Johor. In addition, 344 questionnaires were also sent to senior QS who work in PWD and private QS consultants which provide cost consultancy service to the government (refer to Table 2). About half of the questionnaires were returned (46% — 157 responses). PWD officers and QS consultants returned 45% and 46% of the total respectively. All respondents from PWD are senior officers

Table 2

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Respondents’ organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PWD</td>
</tr>
<tr>
<td></td>
<td>Count</td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>0</td>
</tr>
<tr>
<td>5–10 years</td>
<td>30</td>
</tr>
<tr>
<td>11–15 years</td>
<td>33</td>
</tr>
<tr>
<td>&gt;15 years</td>
<td>41</td>
</tr>
</tbody>
</table>
while 75.5% of respondents from private consultants are senior executives. Almost 92% of total respondents are considered having experience in estimating because most of them have been working for more than 5 years as QS. 40.1% of respondents have been working for more than 15 years in their respective organization. Therefore, this survey has achieved its target in having experienced respondents.

3.2. Sample size for linear multiple regression

Dattalo (2008) suggests the use of G*Power software to determine the sample size needed. In empirical research, statistical inference about a population could only be made through an adequate sample size. However, the access to data depends on the permission of the owner; the author decides to limit the sample size to 80. Field (2009) points out the distributions of the parameter. Field (2009) suggests a sample size of 80 is always adequate sample size. However, the access to data depends on the permission of the owner; the author decides to limit the sample size to 80. Field (2009) points out the distributions of the parameter. Field (2009) suggests a sample size of 80 is always enough with 20 predictors to find a large effect size for linear multiple regression analysis. The following calculation used G*Power software in order to determine the sample size for multi regression model (Faul et al., 2007):

\[
\lambda = f^2 N
\]

\[
26.95 = (0.35) \times N
\]

\[
N = 77
\]

Effect size = \( f^2 \) at 0.35

Non - centrality parameter

\[
\lambda = 26.95 \left( \alpha = 0.05, \text{ power of } 1-\beta \text{ error probability } = 0.80 \text{ and number of predictors } = 20 \right)
\]

Estimated number of sample = \( N \).

3.3. Conventional analysis on the accuracy

Percentage error or a multiplicative approach measures the bias. It measures the percentage differences between estimate and tender bid. Here, the percentage difference between estimate and bid is chosen because in theory, the value of the bid is the one that QS would like to estimate. Arithmetic mean of forecast/tender bid ratio measures the distribution of biases. Coefficient of variation of ratio forecast/tender bid (cv) measures consistency of the estimate:

\[
\text{cv} = \left( \frac{X}{Y} \right) \times 100\%
\]

\( X = \text{standard deviation of ratio forecasts/tender bids} \)

\( Y = \text{mean of ratio forecasts/tender bids} \).

Adjustment has to be made using mean of the bids to measure the forecast quality. The mean calculation uses only eight (8) bidders, as they are limited and if more than eight bidders, the chances of uncompetitive tenders remained in the analysis is high (Carr, 2005; Dell’Isola, 2002; Skitmore, 2002).

3.4. ANOVA test on mean estimate bias

Factorial ANOVA between groups examines the bias (error) of the estimate against the project characteristics, which includes the groups of factors. Field (2009) points out the distributions of the parameter. Field (2009) suggests a sample size of 80 is always enough with 20 predictors to find a large effect size for linear multiple regression analysis. The following calculation used G*Power software in order to determine the sample size for multi regression model (Faul et al., 2007):

3.5. Levene’s test on consistency

Levene’s test investigates whether the consistency varies in each project characteristics. It measures the equality of the variance. The analysis used Levene’s test because it is less sensitive to skew distribution. Analysis uses median value as it provides robustness against non-normal data (Schultz, 1985).

3.6. Linear multiple regression analysis on the estimate bias

It investigates the relationship between the estimate bias and project characteristics. The analysis assumes linear relationship between variables. According to Field (2009), any research looks for real-life relationships should adopt linear multiple regression (LMR). The analysis uses “stepwise technique” for selecting and removing predictors in the model. It must meet the parametric assumptions of the model that includes several assumptions on multicolinearity, homoscedasticity, normally distributed errors and number of extreme cases that affects the model. Errors increase or decrease with some variable such as contract value which depends on the way the error is measured. For example, if the dollar difference between bids and estimates, the LMR may find a positive correlation with project value. Then again, using percentage error, it may find a negative correlation with contract value. It is very important because the correlations between variables are much depending on the way bias is measured.

3.7. Analysis on questionnaire survey

The chi-square test is used to examine differences with categorical variables. It tests whether the groups of respondents’ responses are different significantly from the expected frequencies and the observed frequencies (Field, 2009). Mann–Whitney test is used on ordinal questions that are based on five (5) points Likert’s Scale. It looks for differences in the rank between two independent samples. It tests whether the populations from the two samples are drawn from the same distribution (Field, 2009). It is assumed the answered questionnaire survey follows non-parametric distribution.
4. Results

4.1. Initial data analysis

Tables 3 and 4 show the parameter of estimating bias. The scores of accepted bid and mean of the bids give a similar parameter value. According to paired-samples t-test, there is no significant mean difference between the mean of the bids’ errors and accepted bid’s errors (P > 0.05) but there is a significant mean difference between lowest bid’s errors if compared to other estimating targets (mean of the bids and accepted bid) (P < 0.05). At 95% confidence interval, all estimates were overestimated. Table 5 shows initial analysis on project characteristics.

4.2. Analysis on elemental cost estimate

Table 6 shows the accuracy according to elemental costs. Most of the time, area method is used to estimate the building costs. Other elements used various methods such as approximate quantities and percentage allowances. Piling and foundation recorded the highest mean error at 44.52%. Two (2) projects were estimated without piling works but four (4) projects did not require piling works at all during tender stage. It is followed by external works at 42.86%, building works at 24.26% and internal services at 3.63%. Preliminaries are found with the least mean error at 0.58%. Internal services are the most consistent estimates at 198.25cv. Building works at 49.26cv, preliminaries at 3.63%. Preliminaries are found with the least mean error at 20.61cv. It is followed by building works at 49.26cv, preliminaries at 59.61cv and external works at 69.20cv. Piling and foundation is the most inconsistent estimates at 198.25cv. Building works contributed 48.33% of the total construction cost, which is the highest. It is followed by internal services at 24.67%, piling and foundation at 11.66% and external works at 9.99%. The lowest is preliminaries, which is at 5.35%.

4.3. ANOVA test on mean bias

ANOVA test examines mean bias of the estimate varies in different project characteristic. Shapiro–Wilk test shows only few groups are not equally distributed (P < 0.05). These include the group of more than RM 5,000,000, 2501–3500 m² and secondary school in lowest bid and 2 story heights in accepted bid. It was found that all the groups in estimate/mean of the bids are equally distributed. Table 7 shows the error variances of outcome variables are equal across the groups in all models.

ANOVA test results show there are significant differences between the mean biases in the groups of factors (P < 0.05) which is price intensity (F = 8.122, η² = 0.296), state of project (F = 3.674, η² = 0.202) and type of school (F = 5.917, η² = 0.350) while other factors are not significant (P > 0.05). At 95% confidence interval, all estimates were overestimated. Table 5 shows initial analysis on project characteristics.

Table 3
Mean bias using different estimating targets.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>N</th>
<th>Bias (%)</th>
<th>Consistency (cv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate and lowest bid</td>
<td>83</td>
<td>25.05</td>
<td>11.13</td>
</tr>
<tr>
<td>Estimate and accepted tender bid</td>
<td>83</td>
<td>11.18</td>
<td>9.63</td>
</tr>
<tr>
<td>Estimate and mean of the bids</td>
<td>83</td>
<td>10.88</td>
<td>9.54</td>
</tr>
</tbody>
</table>

Table 4
Bias parameter according to different estimating targets.

<table>
<thead>
<tr>
<th>Target</th>
<th>95% confidence interval</th>
<th>Percentile 25th, 50th and 75th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest bid</td>
<td>22.01 (L), 28.09 (U)</td>
<td>16.43, 25.48, 33.57</td>
</tr>
<tr>
<td>Accepted bid</td>
<td>8.84 (L), 13.52 (U)</td>
<td>4.88, 11.28, 18.54</td>
</tr>
<tr>
<td>Mean of the bids</td>
<td>8.57 (L), 13.19 (U)</td>
<td>3.57, 11.86, 19.10</td>
</tr>
</tbody>
</table>

Note: L = lower value, U = upper value

Table 5
Initial analysis on project characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Lowest bid</th>
<th>Accepted bid</th>
<th>Mean of the bids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bias cv</td>
<td>Bias cv</td>
<td>Bias cv</td>
</tr>
<tr>
<td>Project value (RM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–1,000,000</td>
<td>16</td>
<td>17.39</td>
<td>14.96</td>
<td>3.62, 12.08</td>
</tr>
<tr>
<td>1,000,001–3,000,000</td>
<td>33</td>
<td>26.10</td>
<td>20.44</td>
<td>12.43, 8.93</td>
</tr>
<tr>
<td>3,000,001–5,000,000</td>
<td>22</td>
<td>26.81</td>
<td>9.92</td>
<td>11.09, 8.62</td>
</tr>
<tr>
<td>&gt;5,000,000</td>
<td>12</td>
<td>28.88</td>
<td>7.63</td>
<td>18.01, 5.24</td>
</tr>
<tr>
<td>Project size (m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–1500</td>
<td>31</td>
<td>19.84</td>
<td>12.49</td>
<td>5.85, 10.95</td>
</tr>
<tr>
<td>1501–2500</td>
<td>23</td>
<td>27.26</td>
<td>11.39</td>
<td>13.78, 7.95</td>
</tr>
<tr>
<td>2501–3500</td>
<td>21</td>
<td>28.30</td>
<td>8.20</td>
<td>15.45, 8.14</td>
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<tr>
<td>&gt;3500</td>
<td>8</td>
<td>30.38</td>
<td>9.03</td>
<td>13.19, 6.31</td>
</tr>
<tr>
<td>PI (cost/m²GFA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest bid*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–1000</td>
<td>13</td>
<td>40.25</td>
<td>10.50</td>
<td></td>
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<tr>
<td>1001–1500</td>
<td>39</td>
<td>23.65</td>
<td>7.60</td>
<td></td>
</tr>
<tr>
<td>1501–2000</td>
<td>18</td>
<td>23.21</td>
<td>9.52</td>
<td></td>
</tr>
<tr>
<td>&gt;2000</td>
<td>13</td>
<td>16.63</td>
<td>14.81</td>
<td></td>
</tr>
<tr>
<td>Accepted bid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–1200</td>
<td>16</td>
<td>16.22</td>
<td>7.54</td>
<td></td>
</tr>
<tr>
<td>1201–1700</td>
<td>40</td>
<td>11.85</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>1701–2200</td>
<td>14</td>
<td>10.79</td>
<td>9.15</td>
<td></td>
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4.3.3. Estimate/mean of the bids

- Project size of 1–1500 m²GFA has a significant mean difference if compared to other project sizes.
- Price intensity value of RM 1–1000 m²GFA has a significant mean difference if compared to other price intensity values. Price intensity value of more than RM 2201/m²GFA has a significant mean difference if compared to other price intensity values but it has no significant mean difference if compared to RM 1701–2200/m²GFA.
- The state of Malacca has a significant mean difference if compared to other states. N9 has a significant mean difference if compared to the state of Perak.

4.4. Levene's test on consistency

Levene’s test of homogeneity of variance examines the equality of variances in each of the project characteristics. Contract period has unequal variances (heterogeneous) if compared to other project characteristics. Thus, it affects the estimating consistency. In estimate/accepted bid, the result shows df1 = 2, df2 = 80 and statistic = 4.193 (P < 0.05). In estimate/mean of the bids, the result shows df1 = 2, df2 = 80 and statistic = 4.193 (P < 0.05).

4.5. Linear multiple regression analysis on estimating bias

LMR demonstrates the relationship between project characteristics and estimating bias. It uses a number of estimating targets from lowest bid, accepted bid and mean of the bids as outcome variables. There are the nine (9) project characteristics regressed for linear relationships. Predictors of state, type of schools and class of projects are converted into dummy variables because these are categorical variables (nominal scale). \( \beta_0 \) is for intercept, \( \beta_i \) for beta (predictors) and \( \epsilon \) is random error of \( Y \). The adjusted formula contains 14 predictors as follows:

\[
Y = \beta_0 + \beta_1(\text{Contract Value}) + \beta_2(\text{m²GFA}) + \beta_3(\text{cost/m²GFA}) + \beta_4(\text{Storey}) + \beta_5(\text{Contract Period}) + \beta_6(\text{Number of Bidders}) + \beta_7(\text{Kedah}) + \beta_8(\text{Perak}) + \beta_9(\text{N9}) + \beta_{10}(\text{Malacca}) + \beta_{11}(\text{Johor}) + \beta_{12}(\text{Primary school}) + \beta_{13}(\text{Secondary school}) + \beta_{14}(\text{Main building}) + \beta_{15}(\text{Ancillary building}) + \beta_{16}(\text{Mix building}) + \epsilon.
\]

Table 8 shows the results from LMR. All models from different estimating targets are useful (P < 0.05) with F-value at 10.720, 25.984 and 13.762 respectively. The predictors of...
the models have taken into account 19.2%, 37.9% and 38.4% ($R^2$ Adjusted) of variance in $Y$. The model from estimate/mean of the bids has the lowest standard error of the estimate than the others at 8.306. The model from lowest bid and accepted bid have a higher standard error of estimate at 12.514 and 8.441 respectively. A model with a smaller standard error of the estimate is better.

Residuals are randomly dispersed around zero, which suggests no violation of homoscedasticity. Co-linearity diagnostics show no models have a condition index that more than 15, which suggests no real serious problem in relation to multicolinearity (Tabachnick and Fidell, 2007). Table 9 shows that residuals in all models are normally distributed ($P<0.05$). Case-wise diagnostics show that six cases of standardized residuals in lowest bid model have values outside $+/-2.00$. Meanwhile, accepted bid and mean of the bids models only have three cases outside this limit and no cases in all models are more than $+/-3.00$. The regression equations are as follows:

$$Y_{\text{estimate/lowest bid model 1}} = 34.986 - 0.004 \text{ (cost/m}^2\text{GFA)} - 8.190 \text{ (primary school)}$$

$$Y_{\text{estimate/accepted bid model 2}} = 15.386 - 16.465 \text{ (Malacca)} - 5.986 \text{ (primary school)}$$

$$Y_{\text{estimate/mean of the bids model 3}} = 0.588 - 11.727 \text{ (Malacca)} + 0.002 \text{ (m}^2\text{GFA)} + 0.363 \text{ (number of bidders)} + 4.610 \text{ (secondary school)}$$

4.6. Questionnaire survey on estimating bias

The respondents were asked which estimation value is the most acceptable for public client. More than half (59.2%) of the respondents from PWD and private QS consultants agreed that the overestimate was the most acceptable value for public client. Underestimate was the least agreed by respondents (10.2%). More than a quarter of total respondents, (30.6%) did not know about which values were more acceptable. Chi-square test shows there is a significant difference between type of respondent’s organization and level of tolerances, $\chi^2(2)=7.060, P<0.05$. Even though more than half from both sectors agreed with overestimated value, there were considerable respondents (37.5%) from PWD who did not know which value is more acceptable to government.

The respondents were asked whether they intentionally mark-up their estimates to reduce the risk of underestimation. Close to half the number of respondents (48.4%) did it. Less than half of respondents (43.9%) disapprove of it. Few respondents (7.6%) said they are clueless. Chi-square test shows there is no violation of homoscedasticity. Co-linearity diagnostics show no real serious problem in relation to multicolinearity (Tabachnick and Fidell, 2007). It shows that regression model from estimate/mean of the bids models only have three cases outside this limit and no cases in all models are more than $+/-3.00$. The regression equations are as follows:

$$Y_{\text{estimate/lowest bid model 1}} = 34.986 - 0.004 \text{ (cost/m}^2\text{GFA)} - 8.190 \text{ (primary school)}$$

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5. Discussion

5.1. Estimating accuracy in Public Works Department

Most of the time, the estimates are overestimated. The occurrences of underestimated estimates are unlikely. Research by Gunner and Skitmore (1999b) and Aibinu and Pasco (2008) also shows the same result. Overestimate is more acceptable to QS and Client (Cheung et al., 2008; Magnussen and Olsson, 2006; Skitmore and Cheung, 2007). QS are deliberately bias rather than by mistake because they want to achieve certain result (Flyvbjerg et al., 2002). Nevertheless Soo and Oo (2007) point out QS overestimate the estimate because of the lack of information. This shows that QS try to reduce the risks by increasing the level of price. However, in terms of estimation bias, the estimate is acceptably accurate because the value is $+/-20\%$ which is within the value of $+/-26\%$ by Morrison (1984). He finds that the estimate never getting any better when it is prepared based on traditional estimating method.

The estimate is consistent because the value of coefficient variation (cv) is at 10% to 11% which is nearer to 9% cv. It is because substantial design is already completed when using standard pre-design plans (Ashworth and Skitmore, 1982). According to Skitmore and Ng (2000), consistency of preliminary estimate is suggested at around 15% cv if the estimate uses preliminary design. Accuracy of elemental items shows a high margin of bias and highly inconsistent estimate. The mean bias using area method is 25% for building works. The mean bias for foundation and external works using average percentage allocation is 45%. The use of area method and approximate quantities gives a mean bias of around 20–30% and 15–25% respectively (Boussabaine, 2007; Skitmore and Patchell, 1990). Perhaps, this
gives us the indication that a less rigorous estimating method was used or lack of information supplied to prepare the estimate. The use of more rigorous estimating method may improve the accuracy but if the underestimates is unfavorable; the persistent bias could still be presented. The estimate appears to be accurate because of the effect of error canceling e.g. underestimated estimates were covered by other overestimated elements (Morrison, 1984).

5.2. Best model to explain bias estimate

The estimate is extremely biased if lowest bid is used because of the lowest price submission. The PWD selects the group of tender prices from the mean of the bids and the system is based on average bid method (Public Works Department, 2004, 2005). The use of accepted bid as target is bias because QS and clients could determine the level of price. The use of mean of the bids is better because it has less suicidal low bids but it could be intervening by the uncompetitive bids (McCaffery, 1976; Raftery, 1991). The regression model from mean of the bids shows project size, number of tenders, type of schools and state are the best-fit predictors to explain the bias estimate. It has the largest value of adjusted R². It shows that mean of the bids is the most appropriate target to measure the accuracy of the estimate in the PWD. Lowest bid is not the suitable target to measure the estimating performance in the respect of competitive tendering in the PWD.

5.3. Factors which affects the accuracy

5.3.1. Project value (RM) and project size (m²GFA)

Bias increases with project size is consistent with the findings by Kiew (2009) in Sarawak and Skitmore and Drew (2003) but the former is more negatively biased. It is different if compared to Morrison and Stevens (1980), Skitmore and Tan (1988) and Gunner and Skitmore (1999a) and Aibinu and Pasco (2008). There is some reason on this phenomenon. QS in the PWD are more biased towards more expensive and large project size as those projects are more complicated with less information especially on foundation and external works. The estimate of expensive projects is more consistent. It contradicts the finding by Ogunlana and Thorpe (1991) in which large project is less consistent. It may happen due to the importance of large projects to QS than small and inexpensive projects. QS are consistent in increasing their pricing margin for expensive projects regularly but not for cheap projects.

5.3.2. Price intensity theory (RM/m²GFA)

The finding of price intensity theory in terms of cost/m²GFA which was suggested by Gunner and Skitmore (1999b) and Skitmore and Drew (2003) is similar to this finding. Buildings with low unit rate were overestimated, while high unit rate were underestimated. This price intensity variable is significant in LMR but if lowest bid is the target. Nevertheless, the outcome shows that price intensity is not the significant predictor in mean of the bids. This happens because of some confounding variables in the model (Gunner and Skitmore, 1999b).

5.3.3. Number of bidders

The additional number of bidders led the estimate to be more biased. LMR shows the predictor is significant in estimate/mean of the bids. It contradicts the findings by Harvey (1979), and Flanagan and Norman (1983). Here, bidders decreased their bid amount when they are expecting more bidders enter the bid but QS does not expect this trend and they are unlikely to follow suit. Consistency improves in the mean of the bids with additional bidders entering the bid. Findings by Skitmore (2002) show that consistency decreases with additional number of bidders in seven data sets and the trend was found reversed in other three data sets. Therefore, the relationship between consistency and number of bidders is unclear. It contradicts the bidding model efficacy that suggests that consistency decrease with the additional number of bidders. One possible explanation is most of cost data are pooled from a large number of bidders, which has almost same level of competition. The estimation consistency reduce when QS needs to predict future projects that have a smaller number of bidders. The use of accepted bid as the target has no significant linear correlation with the bias (refer to Fig. 1). It affords the observation of the trend for future research especially for cost modeling purposes due to the intervention of clients and designers in selecting the appropriate prices. The use of accepted bid may contradict the effect of competition. The number of bidders was regressed using linear and logarithmic curve estimation. The number of bidders is found significant (P<0.05) if estimate/mean of the bids is used but not for other targets. Fig. 2 shows mean of the bids above estimate against number of bidders.

5.3.4. Location (state)

There are bias differences between state to state (location) which is similar to the findings by Ogunlana and Thorpe (1991) and Harvey (1979). According to Pegg (1984), the different prices for labor and materials in each location have caused the bias. ANOVA test shows high impact (effect size) of state variable. Malacca and Negeri Sembilan are grouped in the same location (refer to Table 10). However, the finding shows that the differences between these two states are statistically significant. Although Peninsular Malaysia is small, there is a local economic impact on

![Fig. 1. Scatter plot shows bias (%) against number of bidders.](image-url)
the construction prices due to economic disparity between the states as the demand and supply in the states are different.

5.3.5. Types of schools

ANOVA test shows that the type of school has significant mean differences in lowest bid and mean of the bids. LMR shows that all comparisons are statistical significant. These are similar to findings of Harvey (1979) and Morrison and Stevens (1980), but their results are based on different types of schemes. The information regarding the complexity of the design involved is not available but it was made known to the authors that the designs of these schools are different. It could happen because of the design complexity for secondary schools. It shows that the secondary school is biased than primary school.

5.3.6. Contract period

It was found that only contract period is statistically significant for consistency homogeneity. The consistency improves when contract period increases. Findings from Skitmore (1988) and Gunner and Skitmore (1999a) show that no conclusion can be made. The estimates for small projects, which have shorter construction period, are most likely unpredictable than bigger projects. The use of the same group of historical cost data may not be reliable if there is a difference between the contract period of new project and previous project. It is suggested that the pooling of cost data for the estimate of new projects should also reflect the contract period of historical project data.

5.4. Overestimating bias in PWD cost estimation

The earlier discussion discusses the findings based on least squares but not the procedure biases embedded in the PWD practice. As usual, the Government of Malaysia through Ministry of Finance (MOF) sets aside allocation for public projects according to its annual plan, which depends on expected economic conditions. What happened during that year was that the government tried to improve the decline economy through fiscal instrument under the Ninth Malaysia Plan (2006–2011). The development plan took place ahead of general election in 2008. Under the treasury requirement, public money allocated yearly must be fully spend by all project implementers e.g. PWD (National Audit Department, 2007). One of the allocations provided for PWD was to construct additional pre-design school projects around Malaysia, in which the data samples were collected for this research. To confirm the allocation provided, PWD prepares preliminary cost estimate.

The trend shows overestimation of projects when project value (RM) increased. One possible explanation is the QS officers try to maximize the budget allocated. In order to do so, elemental costs for piling and external works were priced higher as these are more risky than the other elements. Over-estimation could provide a safety net if the tender prices are on the high side because QS officers also need to make sure that the budget allocated is sufficient during the tender stage and this leads to the project being started within the one-year time frame provided by MOF. This reduces another round of process to request for more budgets.

It shows that QS officers are more likely to fulfill the budget requirement rather than to leave the estimate as it is. According to Raftery (1995), public clients prefer not to under-spend budgets because of opportunity costs public money lying idle. The questionnaire result shows that the private QS consultants which are hired by PWD are unlikely to “adjust” their estimate because they are less likely to work under the pressure of the government procedure. According to Wachs (1990), bias estimation happened because of organization loyalty towards its superior directive order rather than scientific objectivity. Questionnaire survey shows that QS in PWD expected the estimate to be priced higher than the theoretical value which has a near to zero mean.

The bigger the project, the more extensive are the piling and external works required. It is because only design works for buildings are standardized and others are not. Lack of information during this stage may lead QS officers to find justification to maximize the use of the budget. This might be true because Cheung et al. (2008) describe that most clients did not consider accurate estimate as the important criteria for estimating performance. Their primary concern is more on cost sensitive elements. The reward of making such estimation error (overestimation) is not to underutilize the budget. The questionnaire result also shows that the importance of cost planning is not a critical procedure for PWD.

Table 10

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officers. The result rejects the idea that the client could have better cost planning provided by Cheung et al. (2008). QS in PWD used intuition to identify cost sensitive elements. It means PWD is less likely to prepare a detailed estimate through more definite cost planning because they are more concerned about the time taken to roll out the projects and amount of money to be allocated.

6. Conclusion

Overestimation bias was found in this study. However, the estimates are found to be acceptably accurate in terms of bias and consistency. The best linear model to explain the accuracy of preliminary cost estimate in the PWD is the data from estimate/mean of the bids when compared to other estimating targets. Project size, number of bidders, type of school and location are significant predictors affect the estimate. Nevertheless, location of project (state) has a larger effect size if compared to others. Contract period affects the consistency of the estimate. The difference when using accepted bid as the target is that it could not show the impending competition in bidding when more bidders enter the contract bidding. This affects the observation of systematic bias in the analysis when using different targets. The comparison between project characteristics and elemental costs shows that lack of accuracy in early design stage is caused by lack of information from designers. Data analysis shows that the element of substructure (Piling and Foundations) and external work elements are the most bias and inconsistent. Foundation work and external work are the ones with less information. This is because piling works and external works are not identical from one project to another due to different soil condition. Perhaps, in order to improve the accuracy of these two (2) elements, engineers concerned should provide more detailed information for these two elements. In addition, building work still constitutes the highest amount of construction works. A larger error in this element affects greatly the total accuracy of construction works. The use of percentage allocation and average cost contributes to more bias estimate. The use of more reliable estimating methods and the improvement of cost data pooling improves the accuracy. In addition, PWD needs to embrace proper cost planning procedure. The present practice that divides state according to group should be revised, as it was found that some state in the same group are statistically different from each other. However, as an alternative, the overestimation bias happened because of directive order from the government that is affected by procedure biases, which required public projects to initiate according to the development plan. Public projects are more often political in nature. The risk of underestimation is that the project could not be initiated on time thus, it may put public officers in difficult position and only with the overestimation bias could they deal with it and the result pleases the top officials and politicians.

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