Time and cost models for building projects using prequalification and contract award data in Nigeria

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Abstract

The purpose of this study was to develop models for predicting the probable completion cost and time of building projects using contractors’ prequalification assessment, the initial contract sum and the proposed contract duration. Data on Contractors’ Prequalification Assessment (CPA), Initial Contract Sum (ICS), Planned Contract Duration (PCD), Project Completion Cost (PCC) and Actual Contract Duration (ACD) for 77 completed building projects were sourced from Bureau of Public Procurement (BPP). Multi-collinearity test was conducted on the variables in order to avoid multiple correlations among the data before subjecting them to Multiple Regression Analysis (MRA). The goodness of fit of the models derived as defined by the value of R² was found to be 98.2% and 92.80% for cost and time; thus signifying that about 2% and 7% of the residual variations in the independent variables were not included in the cost and time models respectively. The result of the research would therefore be a bold step at selecting competent contractors who can deliver projects to time and within budgeted cost in Nigeria.

Keywords: Award Data, Building Projects, Cost, Nigeria, Prequalification, Time

Introduction

The construction industry is one of the driving industries in the world economy because it has a strong linkage with many economic activities and whatever happens to the industry will directly or indirectly influence other industries and ultimately the wealth of the country (Pietroforte, et al. 2000). Construction sector and construction activities are considered to be one the major sources of economic growth, development and economic activities (Khan, 2008) while the wealth of any nation is also dependent on the success or failure of projects being executed (Okoroafor and Onyeador, 2006). Therefore efforts geared towards improving construction efficiency by means of cost-effectiveness and timeliness would be worthwhile and certainly contribute to cost savings for the country as a whole (Ogunsemi and Jagboro, 2006).

Project performance has long been defined in terms of cost, time and quality and each of these aspects has been the subject of much research (Xiano and Proverbs, 2005). According to Dissanayaka and Kumaraswamy (1999) time, cost, quality target and participants’ satisfaction are the main criteria for measuring the overall success of construction projects. Supporting this view, Oladapo (2000) submits that a project is considered successful when it is completed on time, within cost and to the required quality standard and a project that does not meet any of these objectives is considered to have failed. However, Ogunsemi and Jagboro (2006) observe that cost and time tend to be the most important and visible, always considered as critical because of their direct economic implications if they are unnecessarily exceeded. Construction clients are also becoming more versatile and proactive; hence they are conscious of time, cost and quality of construction projects (Adetola and Ogunsanmi, 2006). Estimation of time has continue to be a major concern and interest to both researchers and constructors (Ifte, Mahiuddins and Abdul, 2002) while clients are now becoming more eager to know...
what their project is likely to cost before venturing into it.

Ogunseimi (2002) also confirms that there is no gainsaying that the problem of time and cost overruns may not yet be over as they still characterize construction projects in most parts of the world, especially in developing countries. In Nigeria, time and cost overruns are common occurrences in the construction industry and these have continued unabated (Odeyinka and Yusif, 1997). Kharbanda and Pirito (1996) assert that there is a plethora of reports on project cost overruns, and it would be a conservative estimate to state that approximately 50% of construction projects encounter substantial budget overrun with overrun values typically between 40 and 200 percent of the initial project cost. Moreover, Aje (2008) observes that there has been a steady increase in the range of methods used for procurement of construction works in the last two decades and there has been no commensurate improvement in the success rate of construction projects. Instead, there have been extensive delays in the planned schedule, cost overruns, serious problems in quality and an increased number of claims and disputes; which have become unsatisfactory to the operation of construction contracts worldwide. It is in consideration of the foregoing that construction clients find it expedient to make numerous decisions towards enhancing the success of their projects from the inception. One of such decisions is the prequalification of contractors prior to the bidding process (Aje et al., 2009).

Prequalification involves the screening of contractors by a client according to a given set of criteria in order to determine their competence to perform the work if awarded the contract. Ng et al., (1999) assert that huge proportion of misappropriated resources could be salvaged through effective contractor selection especially using modalities of prequalification. Thus Russell and Skibniewski (1998) affirm that considerable goals that could be achieved by effective contractor selection through prequalification process include economic cost, quality, risk reduction, safety, completion on schedule and value for money. Previous researchers such as Ojo (2001), Ogunseimi and Jagboro (2006) attempted to establish time-cost formula for predicting project duration only without recourse to contractors’ prequalification assessment. The objective of this study therefore is to develop models that will be suitable to determine the probable completion cost and time of building projects using contractors’ prequalification assessment and tenders submitted by contractors. This is based on the fact that contractors’ prequalification now forms an integral part of the procurement process in Nigeria. This will not only enhance effective cost control and schedule monitoring of construction projects but will also assist construction practitioners and clients in carrying out the right judgment when considering contractors for contract award. This will in turn reduce the incidence of cost and time overruns usually encountered on construction projects in Nigeria.

**Literature review**

The performance of the construction industry in Nigeria has consistently been a source of concern to both public and private sector clients. This is because the Nigerian construction industry is inefficient when compared with the manufacturing sector (Wahab, 2005). Cost and time overruns have become a cankerworm within the Nigerian construction industry with attendant lack of good quality of finished product which does not provide value for money for the client (Ogunsemi, 2002). Construction projects in Nigeria are known for over-shooting their initial cost budget, which invariably means that it is out of initial time schedule (Ogunsemi and Aje, 2006). Nahapiet and Nahapiet (1985) also confirm that an extensive delay beyond budgeted time limit is one of the problems the construction world is facing in the past years. Previous studies have identified cost and time as key performance indicators, for example Kog, et al., (1999) observe that budget and schedule performances are the most important criteria for measuring construction project success. Similarly, Laufer and Tucker (1987) note that cost and time are the two major goals of a construction project which receive relatively more attention than quality.

However, the success of a project depends on a number of factors such as project complexity, contractual arrangements, and the relationship between project participants as well as the competency and ability of the consultants. Chu, et al., (1999) identify proper contractual arrangements as one of the important success factors for construction projects. This implies...
that the engagement of competent contractor should enable clients and the project team members achieve the objectives set for the project. Ogunsemi (2002) confirms that the features of project participants as it affects project performance cannot be overlooked hence selecting a competent contractor is paramount to successful delivery of construction project (Cheung, et al., 2004). On the other hand, Kaming, et al., (1997) identify contractors’ lack of geographical and project type experience as well as non-familiarity with local regulations as the prime variables of cost overruns in construction projects. Therefore clients are always very curious about construction timing and the competency of contractors is measured by their respective abilities to exhibit effective planning techniques to achieve relational line of balance in construction timing.

Lam, et al., (2001) also added that construction project delivery process is full of uncertainty, imprecision, dynamisms, complexities and other cardinals that outweigh subjectivity in the decision making process of contractor selection. To be objective wholly in the selection process, adequate information about contractors should be retrieved in order to determine the competence of all the respective contractors such that unconquered risks do not boomerang back to client. The contractor selection issue is normally one of identifying a contractor who can undertake the client’s project and take it to satisfactory conclusion, i.e. meet the client’s time, cost, and quality expectations (Wong, 2004). Cheung, et al., (2006) assert that one important aspect of bid evaluation is assessing the capability of a prospective contractor in completing a project. Therefore an accurate prediction of contractors’ potential is of vital importance during contractors’ selection and evaluation process. Such prediction enables the identification and classification of contractors’ performance to ease the selection process.

Project cost performance is used to show whether the project adhere to the agreed budget (Cheung, et al., 2004), and this is important because resources are often limited while cost overruns are to be avoided. Project cost performance according to Odusami (2001) is measured in terms of cost overrun i.e. final contract sum less initial contract sum divided by the initial contract sum multiplied by 100.

According to Kometa and Olomolaiye (1996) a project with percentage cost overrun above 20% is regarded as a poor project in terms of cost performance, project that lie between 10% and 20% is regarded as average project, while project whose percentage cost overrun falls below 10% is regarded as an outstanding project. On the other hand, monitoring project time is one of the many challenges for project participants. Time monitoring seeks to assess how well the project adheres to the planned schedule over a period of time. Therefore schedule or time performance is calculated in terms of the percentage increase in the actual completion period over planned completion period, i.e. the difference between the actual completion time and planned completion time multiplied by 100. Those projects whose percentage delay falls below 10% are regarded as outstanding in terms of time or schedule performance, those that falls between 10% and 20% are regarded as average project while those above 20% are regarded as poor project (Kometa and Olomolaiye, 1996).

Adequate planning at early stages of project execution is an important factor in reducing delays and cost overrun in construction projects (Elinwa and Joshua, 2001). The need for a clear intention and understanding of the technical specifications would also reduce bottlenecks in the execution of projects. One of the most essential requirements before award of contract is the assurance that the would-be contractor will deliver a quality project to time and within approved budget. However accurate prediction of contractors’ likelihood performance prior to award of contract has being a great concern to stakeholders in the construction industry. Therefore considering the state of project execution in Nigeria, it becomes imperative to device a means whereby the completion cost and time of proposed project could be determined from the onset based on contractors’ prequalification assessment and the tenders submitted by contractors. This will ensure that only competent contractors capable of delivering a project to the required quality standard, time and within budgeted cost are considered for award.

**Research methodology**

This is an empirical study conducted in two major Nigerian cities: Abuja and Lagos. These
Cities were selected because majority of construction practitioners, clients and contractors have their operation office in these two cities. More importantly, Abuja is the seat of government where a lot of development in terms of construction is currently going on. Data on contractors’ prequalification assessment (CPA), initial contract sum (ICS), number of floors (NOF), planned contract duration (PCD), project completion cost (PCC) and actual contract duration (ACD) for 77 completed building projects within the study area were sourced from the Bureau of Public Procurement (BPP), Abuja. The data were limited to projects with a minimum contract sum of Fifty Million Naira executed between 2005 and 2011. This is because projects of this magnitude are usually considered by the Federal Executive Council through the Bureau of Public Procurement and hence it was easy to retrieve data relating to such project while year 2005 is the year which “Due Process” in contract award was institutionalized in Nigeria.

Moreover, the variables were subjected to multi-colinearity test in order to avoid multiple correlations among them. Variables that were positively correlated were therefore eliminated while the remaining variables were subjected to regression analysis. Ogunsemi (2002) asserts that for accuracy of predictive models, homogeneity of data is very important. Since construction projects fall into different categories such as building, civil and industrial engineering among others, the study focused on building projects. This is because this category of projects are the most common projects executed by any government in Nigeria while data on them are well documented and are also easily retrieved. Moreover all the costs used for the study were adjusted to 2010 prices using building price index (Chan and Kumaraswamy, 1999). This is to harmonize the costs and times of the 77 projects used for this study since they were constructed at different times and possibly different economic conditions (Bowen, 1982).

The resulting models were evaluated for goodness of fit using the coefficient of determination. They were also validated by splitting the original data into two i.e. one set for calibration while the other set was used for validation (Akindele, 1990). Therefore, of the archival data collected, 80 percent (62 projects) were used for model calibration while the remaining 20 percent (15 projects) were used for validation. Validation of the predictive models was done by carrying out a regression test between the observed and predicted values. A good model ought to show a high coefficient of determination ($R^2$) while the intercept and slope should be close to 0 and 1 respectively (Ogunsemi and Jagboro, 2006). Furthermore, a t-test was carried out between the observed and predicted values to assess their significance differences. The hypotheses tested at 5% significance level were as follows:

- $H_0$: There is no significant difference between the observed and predicted values.
- $H_1$: There is significant difference between the observed and predicted values.

Where $t$-calculated is less than the $t$-critical, $H_0$ is accepted and hence signifies a valid model.

**Results and discussion**

The summary of project characteristics used for this study is presented in Table 1. About 49% of the projects were educational buildings while office complex accounted for 30% of the total projects; 7% of the projects were also hospital projects while the remaining were other forms of projects executed by the various Ministries, Departments and Agencies (MDA). Moreover 57% of the projects were executed in Abuja attesting to the fact that there were more construction projects executed in Abuja being the Federal Capital city of Nigeria. Also the cost of the projects ranged between N50M - N1B while the duration also ranged between 16 weeks - 200 weeks. From the above analysis, it can be seen that the projects considered in this study were well documented and hence suitable for the model calibration.
Equation 1 shows the model on final contract sum from which the cost performance can be determined. The first iteration of the model has number of floors as one of its variables, multi-collinearity test conducted on the variables revealed multiple correlations between the number of floors, the initial contract sum and the initial contract duration with a correlation coefficient of 0.794 for number of floors and the initial contract sum; and 0.737 for number of floors and the initial contract duration. Therefore, in order to avoid multiple correlations among the variables in the model, further iteration was carried out by eliminating number of floors from the variables in the model.

The resulting regression equation is thus written as:

\[
CC = 43207508 + 1230712FC + 77831092TA - 287838MC - 1398829HS - 914998PP + 0.979ICS +12393ICD
\]

\( (R=99.1\%, R^2 = 98.2\%, Adjusted R^2 = 98.0\% ) \)

Where CC is the Completion cost, FC = Financial capability of the Contractor, TA = Technical Ability of the Contractor, MC = Managerial Capability of the Contractor, HS = Health and Safety Records of the Contractor, PP = Past Performance of the Contractor, ICS = Initial Contract Sum of the project, ICD = Initial Contract Duration of the project.
Having predicted the final contract sum from the above equation, the cost performance which according to Odusami (2001) is usually expressed as a percentage can be calculated as:

\[
\text{Cost Performance (CP)} = \frac{\text{Final Contract Sum (FCS)} - \text{Initial Contract sum (ICS)}}{\text{Initial Contract Sum (ICS)}} \times 100\% 
\]

From equation 1, the strength of linear association as determined by the coefficient of correlation (R) is 0.991, signifying 99.1% relationship between the dependent variable and the independent variable and hence can be termed perfect relationship. The coefficient of determination as defined by the \( R^2 \) value is also 98.20% while the adjusted \( R^2 \) value is also 98.0% indicating a high degree of fitness of the regression model. The \( R^2 \) value of 98.0% also implies that all variables included in the model are important to the model. The result in Table 4 shows the coefficients and level of significance of the variables in the cost performance prediction model. It is observed that only initial contract sum (ICS) is significant among the variables used for the model. The fact that other variables comprising contractors' assessments in the major prequalification criteria were not significant may be due to the fact that there are reasonable degrees of subjectivity in the assessment of contractors during prequalification exercise (Aje, 2008). Moreover in most cases, estimation and prediction of construction duration is full of uncertainties (Nkado, 1991) and therefore the initial contract duration (ICD) is not also significant to the model.

### Table 3: Result of Multiple Regression Analysis of the Cost Performance Prediction Model

<table>
<thead>
<tr>
<th>R</th>
<th>( R^2 )</th>
<th>Adjusted ( R^2 )</th>
<th>Std. Error of Est.</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.991</td>
<td>0.982</td>
<td>0.980</td>
<td>13047996.33</td>
<td>421.884</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Predictors: Constant, Financial Capability (FC), Technical Ability (TA), Managerial capability (MC), Health and safety records (HS), Past performance (PP), Initial contract sum (ICS), Initial Contract duration (ICD)
indicating that there are no multiple correlations between the dependent and the independent variables in the time performance model. Similarly, the first iteration of the time performance model also revealed multiple correlations between the number of floors and the initial contract sum with a correlation coefficient of 0.794. Further iteration was also carried out by eliminating the number of floors from the variables in the model. The regression equation for the final contract duration from which the project time or schedule performance can be determined is therefore stated as:

\[
\]

\( (R = 96.3\%, \ R^2 = 92.8\%, \ \text{Adjusted } R^2 = 91.90\%) \quad \text{Equation 2} \)

Where CT is the Completion time, FC = Financial capability, TA = Technical Ability, MC = Managerial Capability, HS = Health and Safety Records, PP = Past Performance, ICS = Initial Contract Sum, ICD = Initial Contract Duration.

### Table 4: Coefficients in the Cost Performance Model

<table>
<thead>
<tr>
<th>Variables in the equation</th>
<th>( \beta )</th>
<th>Std. Error</th>
<th>Beta</th>
<th>t-stat.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>43207508</td>
<td>34558778</td>
<td>1.250</td>
<td>0.217</td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>-1230712</td>
<td>991327.48</td>
<td>-0.026</td>
<td>-1.241</td>
<td>0.220</td>
</tr>
<tr>
<td>TA</td>
<td>778310.92</td>
<td>1032367.70</td>
<td>0.015</td>
<td>0.754</td>
<td>0.454</td>
</tr>
<tr>
<td>MC</td>
<td>-287837.70</td>
<td>969026.70</td>
<td>-0.006</td>
<td>-0.297</td>
<td>0.768</td>
</tr>
<tr>
<td>HS</td>
<td>-1398829</td>
<td>1069205.90</td>
<td>-0.027</td>
<td>-1.308</td>
<td>0.196</td>
</tr>
<tr>
<td>PP</td>
<td>-914997.90</td>
<td>776780.90</td>
<td>-0.024</td>
<td>-1.178</td>
<td>0.244</td>
</tr>
<tr>
<td>ICS</td>
<td>0.979</td>
<td>0.025</td>
<td>0.077</td>
<td>39.432</td>
<td>0.000</td>
</tr>
<tr>
<td>ICD</td>
<td>12392.506</td>
<td>15055.173</td>
<td>0.021</td>
<td>0.823</td>
<td>0.414</td>
</tr>
</tbody>
</table>

From equation 2, the strength of linear association between the dependent and the independent variables in the model is 96.3% while the coefficient of determination \( (R^2) \) and the adjusted \( R^2 \) are 92.8% and 91.90% respectively as shown in Table 6. This also indicates a high degree of fitness of this model and implies that about 8.1% of the residual variation in the dependent variable is not included in this model. Table 5 also shows the correlation matrix of the variables in the time performance model indicating that there are no multiple correlations among the variables; hence all the variables in the model are significant to the model. Table 7 shows the coefficients and the level of significance of the variables in the time performance prediction model. The result shows that financial capability (FC), technical capability (TA) and the initial contract duration (ICD) were significant to the model. It can therefore be inferred that a contractor with robust financial ability and technical competence in terms of quality of technical personnel and equipment has the potentials to complete project to schedule. Even though majority of the variables are not significant to the time and cost models but the predictive ability of
the models as defined by the R² values of 98.2% and 92.8% for cost and time respectively is very high. This is therefore an indication of how well the models fit the population (Chan, 1999). The time/schedule performance can hence be calculated from the difference between the actual completion time and the planned completion time divided by the planned completion time multiplied by 100 (Oduami, 2001).

\[
\text{Time Performance} (TP) = \frac{\text{Actual Completion Time (ACT)} - \text{Planned Completion Time (PCT)}}{\text{Planned Completion Time (PCT)}} \times 100\%.
\]

**Table 6**: Result of Multiple Regression Analysis of the Time Performance Prediction Model

<table>
<thead>
<tr>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>Std. Error of Est.</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.963</td>
<td>0.928</td>
<td>0.919</td>
<td>48.26689</td>
<td>99.764</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Predictors: Constant, Financial Capability (FC), Technical Ability (TA), Managerial capability (MC), Health and safety records (HS), Past performance (PP), Initial contract sum (ICS), Initial Contract duration (ICD).

**Table 7**: Coefficients in the Time Performance Model

<table>
<thead>
<tr>
<th>Variables in the equation</th>
<th>β</th>
<th>Std. Error</th>
<th>Beta</th>
<th>t-stat.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>21.598</td>
<td>127.839</td>
<td>.169</td>
<td>0.866</td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>9.902</td>
<td>3.667</td>
<td>0.114</td>
<td>2.700</td>
<td>0.009</td>
</tr>
<tr>
<td>TA</td>
<td>-14.709</td>
<td>3.819</td>
<td>0.156</td>
<td>3.852</td>
<td>0.000</td>
</tr>
<tr>
<td>MC</td>
<td>3.576</td>
<td>3.585</td>
<td>0.039</td>
<td>0.997</td>
<td>0.323</td>
</tr>
<tr>
<td>HS</td>
<td>-2.636</td>
<td>3.755</td>
<td>-0.028</td>
<td>-0.666</td>
<td>0.508</td>
</tr>
<tr>
<td>PP</td>
<td>4.722</td>
<td>2.873</td>
<td>0.068</td>
<td>1.643</td>
<td>0.106</td>
</tr>
<tr>
<td>ICS</td>
<td>1.45 \times 10^{-7}</td>
<td>0.000</td>
<td>0.079</td>
<td>1.583</td>
<td>0.119</td>
</tr>
<tr>
<td>ICD</td>
<td>1.020</td>
<td>0.056</td>
<td>0.923</td>
<td>18.318</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Model validation**

Tables 8 and 9 show the results of the regression test on the cost and time performance models respectively. In Table 8, the coefficient of determination as defined by the R² value is 0.820 while the intercept and the slope are -2.36 \times 10^{-8} and 1.01 respectively.

Similarly in Table 9, the R² value is 0.804, the intercept is -8.76 \times 10^{-10} and the slope is 1.00. It then follows that there is no significant difference between the observed and predicted values of the time and cost models. Furthermore, the result of the t-test shown in Table 10 also shows that the value of the t-calculated is less than the value of the t-critical for both observed and predicted values of cost and
Conclusion

Budget and schedule performances are the most important criteria for measuring construction project success because of their direct economic implications on the performance of building projects if they are unnecessarily exceeded.
It is therefore expedient for clients and construction practitioners to measure the performance of prospective contractors based on these variables. The ability of consultant prequalifiers to predict the performance of candidate contractors during prequalification exercise will further enhance the objective of prequalification. Therefore the cost and time models developed in this study will be useful in predicting the probable completion cost and time of proposed building projects during prequalification and tender evaluation. This will provide early sign of the projects’ likelihood performance in terms of cost and time so that necessary control measures can be adopted by the consultants. It is believed that the practical application of these models will significantly enhance their improvement thereby ensuring the selection of the most competent contractors for construction projects.

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