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Early identification of lowest responsive bid in competitive bidding process of construction projects

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ABSTRACT : *Lowest bid has often been favoured for award of construction contracts in most competitive bidding due to its perceived advantage to the client. However, thispractice has also been found to eclipse with anomalies. For example, some bid figures are unrealistically low because desperate contractors cut down the figure to enhance the chances of winning contracts with the hope to recover the losses during project implementation. As a result, researchers recommends lowest bid that is responsive in place of just any lowest bid for the award. Bid evaluation has been used to identify the most responsive lowest bid where clients go through all bid documents in a process called bid evaluation. This process of bid evaluation could be very tedious if bidders are many. This research develops a model that can identify the lowest responsive bid very early among competitors without the need to go through tedious bid analysis.It is a further research consideration after Carr (2005)"s model. A set of 36engineering projects of diverse magnitude that went through competitive bidding process in Nigeria were obtained and reports on bid analyses collated. Extracted from the reports are the Consultant's Estimate, The Bid Prices, Error Analysis and the Number of Bidders. Literature documents that these fourfactors influence significantly the lowest responsive bid in competitive bidding. Using the four factors as independent variables and the lowest responsive bid as dependent variable,four simple and three multiple regression models were generated and compared along Carr (2005)'s model. Findingsshow that the number of bidders and consultant's estimateare best variables to predict the lowest bid if combined in a regression model. Apart from eliminating unrealistically low bids, the model abstracts the need for tedious bid analysis andreduce the time taken in bidding process.Furthermore, error was found not dependent on the magnitude of a project. Bidders should stick to ethics of estimating to reduce error in bids. Researchers should consider combining three and the fourvariables in future models to determine comparatively, the one that offers the best predictive power.*

KEY WORDS: *competitive bidding, construction project, contractor selection, lowestresponsivebid, number of bidders, pre-bid estimate*

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I. INTRODUCTION

The process of selecting the most responsive bid among more than one bidders on the same construction project is called competitive bidding (CB) (Aje, Oladinrin and Nwaole, 2016). Thissystem of contractor selection is the most common method of jobs distribution in the construction industry (Prajapati, Pitroda and Bhavasar, 2015). The method allows the client to control tender prices and get value for money by awarding contracts based on low bid prices (Alumbugu, Ola-Owo, Saidu, Abdullahi, and Abdulazeez, 2014, Oyeyipo, Odusami, Ojelabi and Afolabi, 2016, Biruk, Jaskowski and Czarnigowska, 2017). In attempt to get better value for investment in the CB system, many models for the contractors' selection have been developed.One of the ways is a system that allows the award of the contract to the lowest offer identified. The consultants analyse only the lowest bid identified among many for the award of contracts (Melandet al. 2012). The basis of bid selection therefore is single criteria which is the price offeredwhile ignoring other selection qualification criteria such as performance record, reputation, turnover and time of completion. It is only when the lowest bid fails to win the contract that the next lowest bid is identified and considered. Apart from price advantage, the lowest bid system tends to reduce some difficulties associated with CB like dealing with large number of documents (Alumbugu, Ola-Owo, Saidu, Abdullahi, and Abdulazeez, 2014).

However, the lowest bid systemoften eclipses withflawsthat affect contract performance(Aje, Oladinrin and Nwaole, 2016). Key among themincludes igniting fierce competition and price cutting, especially whencompetitors are desperate.Sometimes, what the bidderoffersis often too low to be real in effortto enhance chances of winning awards. Such bidder hopes to recover losses through claims during contract implementation.The initial award price in this system could be low but might not guarantee best value for money at the end of the project (Melandet al. 2012) when claims are settled. Claims in itself often breads management challenges which is a main source of construction disputes leading to litigations, delay and even abandonment (Oladapo and Onabanjo, 2009, Bakhary, Adnan, and Ibrahim, 2015). Thus, it is common thatmanagers will have to deal withnot only problems like poor quality work, but delay, litigation and even abandonment (Puri and Tiwari, 2014). Researchers like Sammoura and Elsayed, (2008) andPuri and Tiwari (2014)posit that the fact of a contractor submitting the lowest bid should not automatically guarantee success. Instead,the emphasis should be onthe lowestbid which is realisticand not just any low bid (Shrestha and Pradhananga, 2010; Oladokun, Oladokun **and** Odesola, 2010).In other words, eyes should not be on the lowest bid, instead it should be on the most responsive low bid for the award (Hafez, Aziz and Elzebak, 2015). How to identify the mostresponsive low bid has since been a subject of research enquiry (Carr, 2005).

The lowest bid system soared because the multi-criteria approach in the bid selection process wasfound not only to be tedious and time consuming,but can be extremely slow(Puri and Tiwari, 2014; Patel and Rajgor, 2016). This encouraged the advent of the low bid system in construction. Carr (2005), in attempt to improve the lowest bid selection system usedpre-bid estimate (PBE) and number of bidders(NB) to establish an equation thatpredicts the lowest responsive bid (LRB) during bidding competition. Carr (2005)'s model lessens the time taken in biddingprocess and eliminates the cumbersome bidsevaluationtask, thus, addresses the problems associated with multi-criteria selection approach.However, Carr (2005)'s model has not yet been improvedupon despite deficiencies. For example, the basis Carr (2005) chose PBE and NB as independent variables in the equationwas not scientifically justified. Thereare otherfactors other thanthe PBE and NB which has been found to affect the LRB (Oke, Aigbavboa and Ijie, 2017) in which Carr (2005) did not investigate. It should be investigated if those factorscould improve the robustness of the predictive model.As such, different matrix ofthese factors modelled could generate diverse predictive strengths of the LRB.The basic assumption in this work therefore is that there are other factors that will improve the predictive tendency of the LRB. The research objectives therefore are to:

1. Collate key factors that affect lowest responsive bid in competitive bidding.
2. Establish a regression model for each of the factors that predicts the lowest responsive bid.
3. Pair the factors and establish multiple regression models that predict lowest bid.
4. Compare all the models with Carr (2005)'s model so as to identify the best combination that can better predict the lowest responsive bid in competitive bidding.

II. THEORETICAL FRAMEWORK

Contractor selection involves a client making decision to choose among alternatives. Decision is defined simply as the act of drawing or making conclusions. Oliveira (2007) viewed decisions as responses to situations that may include three aspects namely:there may be more than one possible course of action being considered; decision makers expect future events that are often described in terms of probabilities or degrees of confidence; and then the consequences associated with possible outcomes can be assessed in terms of reflecting personal values and current goals.Models for decision making havebeen proposed in literature.

In the rational decision-making models, a number of possible alternatives from different scenarios are weighed by probabilities and analysed before making the choice. The final choice favours the one presenting the best-expected scenario having the highest probability of outcome (Oliveira, 2007).Similarly, Simons (1977) proposed the ranking of alternatives to get the most appropriate (Turpin and Marais, 2004). Under this method a numerical value is assigned as basis of ranking. Saaty (2008) observed that most models often measure tangible factors using numerical values while in reality there are intangible factors in decision making that should equally be measured for whose measurement methods are still unknown but will improve the quality of decision if measured.Saaty (2008) also discussed the steps in The Analytical Hierarchy Process (AHP) where decisions are decomposed into four steps of defining the problem, structuring the decision hierarchy from top to bottom, construct a set of pairwise comparison matrix using numerical values and then weigh the priorities. The final priorities of the alternatives in the bottom layer are then obtained.The decision making process Figueraet al. (2005) was viewed in light of mathematical science (Saaty, 2008).

In construction related projects, theorised is that a growing number of competitors who are interested in a job depicts that the work has a high potential value to the client (Yuliana, Kartadipura and Taufik, 2016). The more competitive a job the better the value to the client Therefore, contractors take decisions to bid or not to bid

(Oyeyipoet al., 2016), as much as the client who also takes decision on which bid to acceptfor the offer of an award. Many models to help the contractor make rational decisions have been developed (Skitmore, Pettitt, and McVinish, 2007; Aznar, Pellicer, Davis and Ballesteros-Perez, 2016, Yang, Liu and Skitemore, 2018).On the other hand, models have been developed to help the client make choices on whom to award a contract whenmore than one contractor compete for award of a particular contract. Bid evaluation being a multi-attribute method have been used as an objective means to gauge the suitability of contractors and to take decisions(Puri and Tiwari, 2014). The AHPwhich relates to the multi-attributes method of contractor selection has been applied extensively in choosing constrictors for award of contracts in competitive bidding. Under this method, more than one criteriaare assigned discrete values and analysed. Theaggregate of all the criteria ranked is used as basis for the choice of contractor. Many criteria have been suggested by scholarssuch as, to consider cost, time, and quality that is contained in bid amount (Puri and Tiwari, 2014). Other researchers classified the criteria under fivegroups as financial, technical, managerial, health & safety, and reputation (Hatush and Skitemore, 1997a in Puri and Tiwari, 2014).All these criteria are often considered and the successful contractor is the one that the combined bidding value from the multiple attributes is ranked highest.However, there has beena paradigm shift in favour of lowest bid offered(Alumbuguet al. 2014, Biruk, Jaskowski and Czarnigowska, 2017) due to some difficulties experienced with the multi-attribute method. Under this new method, the contractor that submits the lowest offer wins the contract. Furthermore, researchers soon found out that the lowest bid is not often the optimum value for the contract (Hafez et al., 2015). . While the initial award price could be low (Melandet al. 2012) the practice does not often guarantee best value for money at the end of the project.However its uniqueness made researchers to suggest the choice to be based on the lowest bidthat is responsive or lowest responsive bid (LRB) (Sammoura and Elsayed, 2008). The LRB is simply the lowest bid that is realistic and can execute the job without the identified problems associated with the lowest bid system. This has also derived researchers into modelling methods to identify the LRB in an early stage of the bidding process so as to eliminating the unrealistically low bid among others (Carr, 2005).

III. LITERATURE

Competitive bidding is often classified into open and selective competition. While open competitive bidding opens up the competition for every contractor to bid without restrictions, the end of the process often results to a selective bidding process where a short list of bidders prequalified from the open process are allowed to compete in bidding. The competitiongenerally can be viewed on both positive and negative aspectsby the client. As the public sector client is accountable to the public, an open competitive bidding process that is awarded based only on price is highly transparent. Therefore, awarding contracts to the lowest bidder in a competitively bid public project remains a predominant practice (Shrestha and Pradhananga, 2010)**.** However, selecting a contractor based solely on price greatly diminishes the significance of some important criteria such as time and quality. Further, low bid price as the sole award criterion encourages unqualified contractors to submit bids (Herbsman and Ellis, 1992) and also predatory bidding can ensue where bidders submit a very low bid with the intent of recovering their losses through change orders and claims (Crowley and Hancher, 1995). Puri and Tiwari (2014) believes that the unreasonable low bids could either be accidental, deliberate or unqualified contractor bidding in which award could cause extensive delay, cost overrun, quality problems and increased number of disputes. Low bid therefore is not necessarily a criterion for best value (Bedford, 2009, Shrestha and Pradhananga, 2010).More research works have been conducted on bidding. It was noted that research works have concentrated on five key areas in this field (Shrestha and Pradhananga, 2010), namely (a) factors affectingcontractors’ bidding decisions, (b) bidding mark-up calculation, (c) bidder selection process, (d) correlation between number of bidders and bid cost, and (e) correlation between bid cost and finalconstruction cost.

Some scholars have tried to offer a multi-criteria approach in identifying the desired most responsive bid (Puri and Tiwari, 2014). Shrestha and Pradhananga (2010) correlated bid price of public street projects in the US with corresponding number of bidders and the final construction cost.The study showed public clients received the lowest construction bid price if more bidders are involved in the bidding process. There is also a strong correlation between the lowest bid price and the final construction cost, even though no correlation between the lowest bid price and the construction cost growth. The researchers developed a regression model that predicts the final construction cost of a street project given the lowest bid price.Oladokun, Oladokun and Odesola (2010) established a mathematical model that uses the pre-bid estimate to predict the final contract sum of a proposed project while generating data from 82 building projects carried out in Nigeria between 2005 and 2008. The scholars found that the accuracy level of pre-bid estimates prepared by quantity surveyors was between -36.7 and 34.01%. Alumbuguet al. (2014) studied factors that affect the accuracy of pretender price estimate. A questionnaire was administered containing a list of factors among stakeholders. Responses from clients, consultants and contractors were compared and key factors identified. Recommendations related to meticulous approach, inculcation of ethical values and engagement of qualified personnel in pretender estimating so as to obtain accurate estimates.

Upon these, there seems to be research omission in research focus on ways to lessen client's burden regards the bidding processwhen many bidders are involved in a particular project. This can be achieved if the most responsive bid is identified early in the bidding process without the need to go through the entire bidding process in which this research comes in to fill that gap. The findings can therefore eliminate unresponsive bids early without the need for enormous bid evaluation in competitive bidding. The bidding process therefore becomes faster and cheaper on the side of the client.

Variables influencing bids in competitive bidding

Competitors are often expected to offer in financial terms, the offer which forms the main criteria of selecting a contractor. The lowest bid has often been considered most appropriate for award of contracts. This have led to calls for award of contracts to a more responsive bid in competitive bidding process other than to the lowest bid (Sammoura and Elsayed, 2008). In other words, the lowest bid might not be responsive enough to deserve award consideration. In such cases, another bid should be considered.

The bid figure arrived at and submitted by the contractor is influenced by many factors during preparation.These factors can impact on bid success during contractor selection. The level of impact determines the final price offered which in turn determines the level of success of the bid under competition. Such factors have been used as bases to predict the best offer in a competitive bidding process (Carr, 2005). Bedford (2009) identified the consultant's estimate, number of bidders and error limit in a particular submission, while Sammoura (2010) and Shrestha and Pradhananga (2010) opined that the competitors' averaged bidshould influencethe identification and selection of most responsive bid. The four variables namely, consultant's estimate, number of bidders, error and average bid of the contractors form the bases of the research work.

IV. METHODOLOGY

The data obtained consist of hydro engineering projects that went through open competitive bidding in Nigeria. Client's organizations were contacted and reports on bids analyses were obtained. The Sokoto Rima River Basin and Rural Development Authority, and The HadejiaJamare River Basin were the organizations that supplied the data. The organisations are responsible for implementing irrigation and public water supply projects in the North Eastern and North Western regions of Nigeria. A total of 36 completed projects of diverse magnitudes were obtained. The 36 projects were executed between 2015 and 2017involving 220 bids with diverse level of competition. Extracted from the reports were the consultants' estimates and the number of bids for each project. Also, it includes thearithmeticerror and average bid prices. Bids are often corrected by the consultants afterassessing the extent of error, and the corrected figures becomes the one used as contractor's bid.According to Sammoura (2010) and Shrestha and Pradhananga (2010), it represents the actual figure that the contractor intended to offer except due to the error.This research uses the corrected figures as the basis for the average bid figures. A regression model was established for each of the four identified variables and then for the combinations of two variables as in Table 1. The essence is to establish which model offers best predictive strength of the lowest bid among several bids during construction contracting competitions.

Table 1: Independent variables in each equation

Equations	Independent variables			
	CE	ACB	APE	NB
Equation 1	✓			
Equation 2		✓		
Equation 3			✓	
Equation 4				✓
Equation 5	✓	✓		
Equation 6	✓			✓
Equation 7		✓		✓

Key

CE Consultant's Estimate, independent variable (x1)
ACB Average Corrected Bid, independent variable (x2)
APE Average Percentage Error, independent variable (x3)
NB Number of Bids, independent variable (x4)

Seven equations were established using the regression analysis and all the equations compared. The seven equations include that of Carr (2005) by using the same variables so as to reproduce the equation for the sake of comparison. The equationhaving the best predictive power to identifya bon-a'-fide lowest bid (lowest responsive responsible bid) at early stage in a competitive bidding process recommended.

V. RESULTS

Regression models

The regression statistics for the varying equations identified in Table 1 from which the regression equations were developed from SPSS andare presented under this sections.

Simple regression models

This part presents simple regression model cases containing one independent variable. Table 2 is the summary of the regression statistics generated for a regression model between the lowest corrected bid (LCB) and the consultant's estimate (CE).The LCB is the dependent variable Y, and the CE is the independent variable X. The essence is to establish a model that the CE can be used to predict the lowest bid expected in competitive bidding.

Table 2 Regression statistics of Lowest Bids and Consultant's Estimate

Variables entered/removed			
Model	Variables Entered	Variables Removed	Method
1	Consultant's estimate[b]	.	Enter

a. Dependent Variable: Lowest corrected bid
b. All requested variables entered.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.962[a]	.925	.923	7128317.97816

a. Predictors: (Constant), Consultant's estimate

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21233842976340860.000	1	21233842976340860.000	417.883	.000[b]
	Residual	1727639184723022.000	34	50812917197735.950		
	Total	22961482161063880.000	35			

a. Dependent Variable: Lowest corrected bid
b. Predictors: (Constant), Consultant's estimate

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1238837.360	2159532.997		-.574	.570
	Consultant's estimate	.812	.040	.962	20.442	.000

a. Dependent Variable: Lowest corrected bid

The equation connecting X and Y is:

$Y = 0.812X_1 - 1238837.360$ ----------------------------------eqn.1

Where Y is the lowest bid desired and X_1 is the consultant's estimate (CE)

In equation 1, X_1 has a positive effect on Y such that, for any increase of 1 unit of X_1, the mean value of Y is estimated to increase by 0.812 units. In other words, for each 1.0 million Naira the CE increases, the mean value of the lowest bid increases by 0.812 million naira. Note that when X is 0 or rather, when the CE is 0 in the same equation Y attains a negative value. In practical terms, X cannot be 0 for a project, so the value -1238837.36 which is the intercept on Y axis has no practical meaning on its own. In the ANOVA table, the sum of squares total measures the variation of Y around their mean. The sum of square regression is the explained variation which is 2.123E+16 and said to occur due to the relationship between Y and X. The sum of squares residual is the unexplained variation which is 1.728E+15, and isinterpreted as the variation which occurs in Y and cannot be explained. In other words, it occurs due to other reasons other than the relationship between X and Y. The explained variation is much greater than the unexplained to show that changes occur in Y largely due to its relationship with X.

However, it is important to look at the coefficient of determination which is the measure of the proportion of the variation in Y that is explained by virtue of the independent variable X in the regression model. The value R square is 0.925 which means that 92.50% of the variation in the lowest bid (Y) is explained by the variability in the CE (X). In other words the level of dependency of the lowest bid on X (CE) is 92.50%. Only 7.50% of the sample variability in Y is due to factors other than is accounted for by the linear regression model that uses consultants estimate. Thep-value or the significant value is 0.000 using 0.05 level of significance.It can be seen that the p-value is less than 0.05. This establishes that there is a significant linear relationship between X and Y. The lowest bid price, Y is the dependent variable and the CE is the independent variable. Therefore, the changes in Y depends largely on changes in X. The implication is that knowing the engineer's estimates (X) for a new project, the value of the lowest bid (Y) that is expected from bidders can be established. Similar equations were derived for the other three variables which offered different strengths of prediction of Y as presented below.

$Y = 997271.244 + 0.773X_2$ ------------------------------2

$Y = 35649731.44 + 2030573.024X_3$ ------------------------------3

$Y = 44941313.33 - 1552584.514X_4$ ------------------------------4

ACB=X2, APE=X_3, and NB= X_4

Equation 2 predicts the lowest bid using the average of the bids of all contractors (X_2) in a particular project. The average bid also has a positive effect on the lowest bid as per the equation.Asthe average of the contractor's bid increases, the lowest bid among the bid figures also increases as naturally expected. However, in Table 4, if X_2 increases by 1 unit in this case, Y increases by 0.773. The increase here is less than X_1in equation 1 which was 0.812. The coefficient of determination, R square, is 0.802. This signifies that 80.2% of the change in Y is caused by its relationship with X_2 as compared to 92.50% in equation 1. This is a weaker equation comparatively.However, the p value of 0.000 establishes that the effect or contribution to changes in Y is significant.Equation3 uses computational error in bids (X_3) to estimate the lowest bid. The equation shows that for every one unit of increase in error, there is a corresponding increase in the lowest bid figure of 2030573.024 units. This is a much higher figure compared to equation 1 and 2 and also shows that computational errors in the Nigerian construction bidding tend to increase the contract sum instead of decreasing it. However, the R square in Table 4 is 0.000 which shows that the increase in the lowest bid is not explained by its relationship with the increase in error. The increase in Y can be explained by other factors external to the relationship and not due to X in this case. Equation 4 rather indicates that there is an inverse relationship between the number of bids and the lowest bid. It means that, by increasing one bidder in competition, the lowest bid decreases in value of about -1552584.514 units or the lowest offer in competition reduces by about N1.55. Therefore, the more the number of bidders in a biddingcompetition, the less the lowest bid likely to be offered. However, the coefficient of determination is just 0.025 as in Table 4. This suggests that only about 2.5% of the change in the lowest bid can be explained by the reasons of the relationship in the equation. The change in the lowest bid as suggested here is largely due to external factors that cannot be explained and not by reason of the relationship with the number of bidders solicited.Therefore there's a weak relationship between the number of bidders and the lowest bid. Equation 4 herein marks the end of regression between the lowest bid and a single variable. It suggest here that equation 1 is the best predictor among the four equations.

Multiple regressions models

This section intends to find out if combining more of the identified variables could predict the lowest bid better. Various matrix combinations were made and the results of the regression statistics with the regression models followed below.

Table 3 reports the regression statistic ofa case of paired variables. Since Car (2005) used two variables, the same is used here for the purpose of better comparison. The equation therefore has two independent variables. It means that as one variable is changing, the corresponding effect on the lowest bid considers the effect of the second variable present in the equation.

Table 3: Regression statistics of Lowest Bids and Average Bids & Consultant's Estimate

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Average Corrected Bid, Consultant's Estimate[b]	.	Enter

a. Dependent Variable: Lowest Corrected Bid
b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.963[a]	.928	.924	7069442.90696

a. Predictors: (Constant), Average Corrected Bid, Consultant's Estimate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21312240401577520.000	2	10656120200788760.000	213.220	.000[b]
	Residual	1649241759486359.000	33	49977023014738.170		
	Total	22961482161063880.000	35			

a. Dependent Variable: Lowest Corrected Bid
b. Predictors: (Constant), Average Corrected Bid, Consultant's Estimate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1782276.994	2185207.207		-.816	.421
	Consultant's Estimate	.707	.093	.837	7.606	.000
	Average Corrected Bid	.119	.095	.138	1.252	.219

a. Dependent Variable: Lowest Corrected Bid

Equation 5 is derived from the coefficients in Table 3 which has CE and ACB combined as the independent variables. The regression equation is shown as follows:

$Y = -1782276.994 + 0.707X_1 + 0.199X_2$ ------------5

Y is the lowest bid, X_1 is the consultant's estimate (CE) and X_2 is the average bid (ACB).

Similar equations are derived with different combinations of two variables as follows:

$Y=87545544.303 + 0.814X_1 - 1680451.124X_4$ ------------6*

$Y= 10254315.03 + 0.773X_3 - 1541562.74X_4$ -----------7

In equation 5, X_1 and X_2 have slopes of 0.707 and 0.119 respectively. It means if X_2 is kept constant, the contribution of X_1 to the variation in Y (the lowest bid) when X_1 is increased by1 unit is 0.707 units. By keeping X_1 constant, X_2 contributes 0.119 units if it is increase by 1 unit. The R square of the whole regression is 0.928 and explained as 92.8% of the effect on lowest bid can be attributed to the reason of the regression between Y and the independent variables (X_1, X_2). This is a high degree of dependency. Furthermore, the Sum of Squares Total is the total deviation of the points from the slope that predicts the dependent variable which is 2.296E+16. Out of this figure, 2.131E+16 of the deviation can be explained, while only 1.649E+15 unexplained, theunexplained being comparatively low. The p-value of 0.000 of the entire relationship in the ANOVA in Table 3 is lower than the level of significance of 0.05. This therefore rejects the hypothesis ofno significance and accepts that there is significant linear relationship between the dependent and the independent variables. However, in the p- regression value section of the table, the p value for X_1 is also 0.000 which also rejects the no significance hypothesis at the 0.05 level of significance, showing that the CE has significant effect on the dependent variable. In other words, the CE contributes significantly to changes in Y. The p value forX_2 is 0.219 is however greater than 0.05. Therefore, accept the no significance hypothesis, and conclude that there is no significant contribution of X_2(average bid) to changes in Y on the regression equation. While the average bid showed a significant contribution to changes in Y in the simple regression (see equation 2), it is showing no significant contribution in the multiple regression in this case. Only the CE has significant linear relationship that affects the regression in equation 5. Most of the variation in Y is caused by X_1 and less of X_2.

Considering equation 6, the contribution of X_1 is positive while X_4 is negative. However, the value of R square is 0.954 which means 95.4% of the variation in Y is explained by the regression relationship. Only 4.6% in the changes in Y is due to other factors other than the relationship. Therefore, most of the changes can be explained. The p-value of the model is 0.000 which is less than the level of significance of 0.05. This therefore rejects the notion that there is no significant linear relationship between the dependent and the independent variables. The level of dependency of Y on the independent variables is therefore significant. Both p-values for X_1 and X_4 are below 0.05 which also establishes that the contributions of X_1 and X_4 to the variation in Y is significant. Also note that the effect of X_4 (number of bids) on changes in Y in the simple regression case was insignificant as in equation 4. However, combination with another variable is giving the NB contributing significantly to changes in Y.In the multiple regression case, equation 6 which combines CE and NB offers a better predictive power of the lowest responsive bid in competitive bidding. At this level, equation 6 can be concluded as a good predictor of Y, the lowest bid in a competitive bidding of engineering projects. Similar analysis indicate that equations 5 and 7 performs lower than equation 6. Therefore, equation 6 is the model.

Table 4: Summary of regression statistics of the seven equations generated

	Independent variable	Intercept	SLOPE	R Square (R^2)	STD. Error	SST	SSR	SSE	P-Regression	P-Value
Equations	One variable									
1	-CE	-1238837.360	0.812	0.925	7128317.978	2.296E+16	2.123E+16	1.728e+15	0.000	0.000
2	-ACB	997271.244	0.773	0.802	11556330.54	2.296E+16	1.842E+16	4.541E+15	0.000	0.000
3	-APE	35649731.44	2030573.024	0.000	25986940.45	2.296E+16	5.656E+11	2.296E+16	0.977	0.977
4	-NB	44941313.33	-1552584.514	0.025	25657791.89	2.296E+16	5.785E+14	2.238E+16	0.355	0.355
	Two variables									
5	-CE	-1782276.994	0.707	0.928	7069442.907	2.296E+16	2.131E+16	1.649E+15	0.000	0.000
	-ACB		0.119						0.219	
6	-CE	8754554.303	0.814	0.954	5640825.187	2.296E+16	2.191E+16	1.050E+15	0.000	0.000
	-NB		-1680451.124						0.000	
7	-ACB	10254315.03	0.773	0.872	10968715.163	2.296E+16	1.899E+16	3.970E+15	0.000	0.000
	-NB		-1541562.74						0.037	

VI. DISCUSSION

Table 4 summarises the regression statistics of all the equations derived for easy comparison. The four variables were established to contribute significantly to changes in lowest bid except error (APE) and number of bids (NB). The R^2 in this case is 0.000 which indicates that Y has no trace of dependence on the variable in question. To buttress this, the p value is 0.977 which is greater than 0.05 to indicate that there is no significant contribution in which error makes in determining the lowest bid in competitive bidding. It is on this basis that this work concludes that the influence of error in paired regression equations will not be significant. Further, since the lowest bid is directly related to the value of the project, the implication is that error in bids has less to do with the magnitude or the value of the project. Error is therefore purely based on the estimator's competence. This finding relates to Alumbuguet al. (2014) who recommended in a research for meticulous approach in bid preparation as the best way to obtain accurate pretender estimate. The next insignificant contributor is the number of bids. The p value is 0.335 which is greater than 0.05. However, even though very low, there is some degree of influence of number of bids on Y with R^2 being 0.025. It means Y depends on the number of bids by only 2.5%. Since there is evidence of influence of the number of bids on changes in Y, it is retained for further research consideration while error left out in the multiple regressions computations for lack of influence. The best equation in all is equation 6 which shows 95.4% dependence of Y on the X variables and each of the independent variables contributing significantly to changes in the dependent variable Y.

The second most robust equation is the fifth one which combines the Consultant's Estimate with the Average Corrected Bid (ACB). The R^2 is 0.925 but the p value of one of the variables (ACB) is 0.219 which is greater than 0.05. This indicates that ACB is not making significant contribution to changes in Y. The changes in the dependent variable therefore rests largely on one independent variable which is the Consultant's Estimate.

VII. CONCLUSION AND RECOMMENDATIONS

This research sought to develop and compare a set of equations to obtain the most robust that can predict the LRB in competitive bidding. It is to lessen the burden of rigorous bid analyses experienced by clients when bidding competition for award of construction contracts is high.Equation 6 combines the Consultant's Estimate and the Number of Bids as the independent variables to predict the Lowest Responsive Bid in a competitive bidding system. Equation 6 is found to be the best model when compared with other equations similarly developed. This finding re-establishesthe equation generated by Carr (2005), however with justification in the choice of the variables in the equation. It was able to establish that single variables and otherpaired variablesdo not perform better than the equation established by Carr. Equation 6 is therefore recommended as the best predictor of lowest responsive bid in competitive bidding. The implication is that in a proposed project, the client can use the contract sum and the number of bidders he intends to invite and generate the lowest bid figure that a bidder should offer to be considered as the most responsive. Figures that fall below suggest predatory bidding while those above could suggest over ambitiousness on the side of the bidder. The need to go through all the bids therefore becomes unnecessary yet a reliable lowest bid is identified. If the identified bid fails after considering other criteria, the next responsive bid is considered. A base for negotiation with the next responsive bid has also been established. By identifying the lowest responsive bid to deal with, more attention can be given to other factorslike time and quality criteria consideration in the bid selection process.This research established that error in a bid is not dependent on the magnitude of the project. Contracting organisations should therefore observe all ethics in preparing bids in order to reduce error in their offer, thus improving on the quality of submission with better chances of winning contracts.

However, this research did notconsider combining more matrix for the models. If all the factors are combined in a multiple regression the question is whether a better model will be achieved. More research can be considered by modelling the matrix of three and four variables and comparewith this findings to determine the best predictive model to identify the lowest responsive bid in competitive bidding. Furthermore, the model can best be applied after consultant's estimate has been prepared. Models that can offer the same value earlier can also be considered in future research works.

REFERENCES:

[1]. Aje, I. O., Oladinrin, T. O. and Nwaole, A. N. C. (2016). Factors influencing success rate of contractors in competitive bidding for construction works in South-East, Nigeria. Journal of Construction in Developing Countries, 21(1), 19–34. http://dx.doi.org/10.21315/jcdc2016.21.1.2.

[2]. Alumbugu, P. O., Ola-Owo, W. A., Saidu, I., Abdullahi, M. M. and Abdulazeez, A. (2014). Assessment of the factors affecting accuracy of pre-tender cost estimate in Kaduna State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), 8(5):19-27. Available online on www.iosrjournals.org.

[3]. Aznar, B., Pellicer, E., Davis, S, and Ballesteros-Perez, P. (2017). Factors affecting contractor's bidding success for international infrastructure projects in Australia. Journal of Civil Engineering and Management, 23(7) 880–889. https://doi.org/10.3846/13923730.2017.1341955

[4]. Bakhary, N. Z., Adnan, H and Ibrahim, A. (2015) A Study of construction claim management problems in Malaysia. 2nd global conference on business, economics, management and tourism. ProcediaEconomics and Finance, 23 (2015) 63 – 70.

[5]. Bedford, T. (2009). Analysis of the low-bid award system in public sector construction procurement. A thesis submitted in conformity with the requirements for the degree of Masters of Applied Science Graduate Department of Civil Engineering University of Toronto.

[6]. Bruik, S., Jaskowski, P. and Czarnigowska, J. A. (2017). Modelling contractor's bidding decisions.ProcediaEngineering, 182 (2017) 91 – 98. The 7th International Conference on Engineering, Project, and Production Management. doi: 10.1016/j.proeng.2017.03.125.

[7]. Carr, P.G. (2005), "Investigation of bid price competition measured through pre-bid project estimates, actual bid prices, and number of bidders."Journal of Construction Engineering and Management, 131(11): 1165.

[8]. Crowley, L. G. and Hancher, D. E. (1995). Evaluation of competitive bids. Journal of Construction Engineering and Management, 121(2):DOI: 10.1061/(ASCE)0733-9364(1995)121:2(238)

[9]. Hafez, S. M., Aziz, R. F. and Elzebak, H. M. M. (2015). Optimal Techniques for Cost Reduction and Control in Construction Sites. Journal of Human Resource Management, 3(3):17-26. doi:10.11648/j.jhrm.20150303.11.

[10]. Herbsman, Z. and Ellis, R. (1992). Multi-parameter bidding system—innovation in contract administration. JournalofConstructionEngineeringandManagement 118(1):14250.DOI: 10.1061/(ASCE)07339364(1992)118:1(142)

[11]. Hiyassat, M. A. (2000). Construction Bid Price Evaluation. Canadian Journal of Civil Engineering, Vol. 28, pp. 264–270.

[12]. Oke, A. E.,Aigbavboa, A. E. and Ijie, O. T. (2017) Assessment of qualitative factors influencing contractors tender and project success in an emerging economy. The 53rd ASC Annual International Conference Proceedings 2017 by the Associated Schools of Construction. Available online on https://www.researchgate.net/publication/316005384.

[13]. Oladapo, A. and Onabanjo, B. (2009) A study of the causes and resolution of disputes in the Nigerian construction industry. RICS research conference, University of Cape Town, 10-11th Sept.

[14]. Oladokun, M. G., Oladokun, A. A. and Odesola, I. A. (2010). Accuracy of Pre-Tender Cost Estimates of Consultant Quantity Surveyors in Nigeria. Journal of International Real Estate and Construction Studies 1(1):39-51

[15]. Oliveira, A. (2007). Decision-Making Theories and Models: A Discussion of Rational and Psychological Decision-Making Theories and Models: The Search for a Cultural-Ethical Decision-Making Model. EJBOElectronic Journal of Business Ethics and Organization Studies, 12(2): pp12-17. Available online on http://ejbo.jyu.fi/

[16]. Oyeyipo, O. O., Odusami, K. T.,Ojelabi, R. A. and Afolabi, A. O. (2016). Factors Affecting Contractors' Bidding Decisions for Construction Projects in Nigeria.Journal of Construction in Developing Countries, 21(2), 21–35. Available online on https://dx.doi.org/10.21315/jcdc2016.21.2.2

[17]. Patel, M. and Rajgor, M. (2016). A review on strategy of bidding and competitive bidding process. International Journal of Advance Engineering and Research Development (IJAERD), 3(4): 2348 – 4470.

[18]. Prajapati, R., Pitroda, J. and Bhavasar, J. J. (2015). Analysis of factor affecting contractor's bidding strategy using RII method. International Journal of Modern Trends in Engineering and Research (IJMTER), 02(04):184-187.

[19]. Puri, D. and Tiwari, S. (2014). Evaluating The Criteria for Contractors' Selection and Bid Evaluation. International Journal of Engineering Science Invention, 3(7):44-49. Available online on www.ijesi.org.

[20]. Saaty, T. L. (2008). Decision making with the analytic hierarchy processes. Int. J. ServicesSciences, 1(1):83–98.

[21]. Sammoura, R, (2010). A Simulation Model for Bid Price Decision Making. World Academy of Science, Engineering and Technology.InternationalJournalofEconomics and Management Engineering, 4(5):529532.Fromscholar.waset.org/13076892/14070.

[22]. Sammoura, R. and Elsayed, A. (2008). "Stocastic-simulation model for lowest bid price evaluation: A case study in road construction and rehabilitation projects in Lebanon," in Proc. the First International Conference on Construction in Developing Countries (ICCIDC–I): "Advancing and Integrating Construction Education, Research & Practice," August 4-5, Karachi, Pakistan, pp. 168-176.

[23]. Shrestha, P. P. and Pradhananga, N. (2010). Correlating bid price with the number of bidders and final construction cost of public street projects. Transportation Research Record: Journal of the Transportation Research Board. Transportation Research Board of the National Academies, Washington,D.C.,2151(2151):3-10. DOI: 10.3141/2151-01

[24]. Skitmore, M. R., Pettitt, A. N., and McVinish, R. S. (2007) Gates' bidding model. Journal of Construction EngineeringandManagement(ASCE).133(11):855863.Availableonlineonhttps://www.researchgate.net/publication/43474832

[25]. urpin, S. M. and Marais, M. A. (2004). Decision-making: Theory and practice. ORiON. 20(2):143–160. Available online on http://www.orssa.org.za

[26]. Yan, P., Liu, J. and Skitmore, M. (2018). Individual, group, and organizational factors affecting group bidding decisions for construction projects. Advances in Civil Engineering. pp1-10.Available online onhttps://doi.org/10.1155/2018/3690302.

[27]. Yuliana, C., Kartadipura, R. H., Taufik, S. (2016). Bidding strategy using Friedman model for building construction project in Banjarbaru Indonesia. Journal of Civil, Construction and Environmental Engineering. 1(1):12-17.doi: 10.11648/j.jccee.20160101.12