

Collation of Decision Support System (DSS) Models used for Bid Decisions in Construction Industry



B. S. Mandanna, B. R. K. Holla

Abstract: *The past researches on key elements responsible for the successful completion of the project showed the importance of assessment and accounting of various types of risks during the bid decision process. If the contractor invests his productive time in only those projects which are meeting the organization's goals and targets, then the chances of submitting a competitive bid is more. In order to select such appropriate projects, the measure of the effect of numerous factors on bid decision is essential. This research highlights the numerous reasons that influences the bid decisions of contractors and the contribution of these factors towards the construction of Decision Support System Models (DSS). In order to identify the factors influencing the bid decisions, past literature studies were conducted and a strong focus was given to methods such as questionnaire survey, structured and semi-structured interviews were used. The construction of the models was done after taking the opinions of contractors. From the past research it can be noted that the main factors such as client's financial capability, contractor's financial capability, past experience of the contractors in similar projects etc., were considered across the globe. This complex and dynamic nature of bid decision making demands a robust decision support system which can be implemented collectively at least in a construction industry within a country. Moreover, the bid decision is more of subjective in nature. So, addressing this with only quantitative models which considers past bid data, recently applied strategy etc., may not be adequate to forecast the dynamic phenomenon. This strongly proposes the requirement for development of a Qualitative model to take care of subjective decision-making situation.*

Keywords: Decision Support System (DSS), Bid or No-Bid decisions, Qualitative Models, Construction Industry

I. INTRODUCTION

One of the primary and important decisions which is to be taken by the contractor's working in the industry of construction is whether to bid or not bid for a new project when an invitation comes.

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Making decisions at the initial stages of construction projects involve a process of collecting information from many sources. Clever contractors perceive the importance of considering external as well as internal aspects that mark the bid or no-bid decision before involving themselves towards a project. The decision making at this stage is accomplished by two related decisions: 1) no bid / bid decisions that consider factors which would help to derive the benefit anticipated from a particular project and a suitable strategy for bidding; 2) mark-up decision, which is one of the results of the bidding strategy.[1]

The construction industry is measured as one of the key sponsors to the economy in Palestine. The decision of the contractor to bid or not to bid is uncertain and it may be influenced by numerous factors. Some factors may be related to client, few may be related to the contractor, few to the project characteristics and contract and also to business environment.[2] The importance related to bidding or no bidding and the choice to bid for an unsuitable project and also the high uncertainty and complexity involved in such decision making process involves the consideration of many internal and external factors and this also makes way for considering the critical factors that justify the decision of contractor's to bid or not for a construction project. [3]

A large number of construction industries are small and medium sized in many developing countries. They are mostly indigenous industries and they are described as the engine of growth in the industry of construction. Past literatures have concentrated into the topic of no bid or bid decision factor. These studies are based on developed countries and least attention is given to developing countries. This shouldn't be done as developing countries contribute in a huge manner to the global wealth. Study carried out by [8] eliminates this gap.

The bid decision is the primary stage while considering a given project and it creates a planned choice for any construction company. In Saudi Arabia, it is compulsory for all the contractors to secure the classification certificate and this mandatory for the process of bidding in government projects. The main reasons for the implementation of the classification scheme is to make sure that contractor's bid for projects which suits their sizes. Typically, the procedure of bidding involves two vital decisions which is bid price determination and decision to bid. [9]

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The majority of the models developed are with unfeasible expectations and the complexity of their mathematical processes makes it interesting for the user to understand his reasoning. Thought of many factors and contributions, need for wide interference from the user which limit the correctness of the decision.

Therefore, a considerable extent of understanding is required to arrive at a presentation which is comparable to that of human expertise in the field.

The mark-up range is dependent on the complexity & specialization of job. But mark-up percentages between the two business sectors are not statistically significant. The increased competition in traditional areas like buildings, roads, factories tends to pull the mark-up level down. From the study, it can be concluded that both variables i.e. 'mark-up size' & 'Number of the successful bid in different project size' are independent of each other. [21]

Thus, the chief goal of this study is to find and evaluate the causes that contribute to the bidding decisions of contractors and to study the quantitative bid decision and mark-up decision models.

II. FACTORS CONTRIBUTING TO DECISION ON BID OR NO-BID IN CONSTRUCTION

According to Enshassi et al., (2010) [2] The main reason of the study was identification of the factors and rank the ones disturbing the no bid or bid decision in terms of importance from the view of the contractors in Gaza, Palestine. The main aim of the study was investigation through postal questionnaire to 29 clients, 13 consultants and 63 contractors operating in Gaza strip's construction industry. The questionnaire was structured on the basis past literatures, preliminary study and the real factors influencing the decisions of bidders to bid or not which arises due to special conditions existing in Gaza. The results show that the financial ability of the contractors, clients, project, the remaining payment dates, raw material availability for the construction and construction industry's solidity were the important factors influencing the bid decisions. This paper tells that the Relation between contractor and subcontractor were ranked the least and the results reflect the relation between them need to be strengthened and supported. It is also suggested that consultants and clients should consider the staff competencies, technological capabilities and financial capabilities of the contractors throughout the process of awarding the bid and not to concentrate just on the lowest bid.

According to M. Jarkas et al., (2013) [3] there are high level of complexity and uncertainties involved in a decision-making process for suitable contracts. The hosting rights of FIFA World Cup was awarded to Qatar. The study was mainly done to recognize, discover and also to rank the importance of different factors responsible for the contractors bid decisions considered for the local projects. In order to achieve this aim, questionnaire survey consisting of 43 factors based on past research related to practices of bidding was done. Using 'Relative Importance Index' following factors were determined namely size of the project, need for work, present workload, quality level of the tender documents, punctuality of employer in the process of payment, previous

experience in similar kind of projects, past work experience with the employer, identity and reputations and also financial firmness of the employers and availability of other projects. The results of this research encouraged other researchers to do this study in their particular countries so that the factors developing helps in understanding the more complex issues and also can serve as a base for cross-comparisons among the factors that help a contractor to bid in this competitive construction industry. This was further reinforced by the factors like whether there is a need for the work? what is the current work load of the organization? i.e., whether the organization has any idle resources? etc.

According to Dey et al., (2018) [4] This study presents the analysis of factors influencing the contractors bid decision, mark-up percentage of 17 different respondents from top five contractors in highway sector across India, relationship between successful bid ratio with firm's net profit margin (NPM) & total revenue, relationship between mark-up size with successful bid ratio in different construction business sector & mark-up size variations in different construction sector by applying various research methods like RII method, descriptive statistics, chi-square test of independence and spearman correlation coefficient method. Financial capabilities of the contractor, experience in similar projects, contractor staff's competency, relation between the bank and contractor, availability of equipment possessed by contractors are the major factors connected to contractor, influencing the bid decision. Client's financial capabilities, payment policy, client's reputation, client's policy for reward are some of the top main driving factors related to the client, that influence bid decision of contractors. Size, number of competitors & intensity of competition, Project cash flow, cost & intensity of the project, rise in material prices, kind of project-buildings, project duration are the major factors that influence mark-up size of contractors. The study can also be conducted to verify the similarity between client and contractor's perception.

According to Chileshe and Ghasabeh., (2015) [5] a study was conducted to examine and rank the important factors that influences bid decisions and the importance of those factors in the Construction Industry of Australia. A total of 26 most common no-bid or bid decision making factors were identified and were gathered into five different groups that is contractor, contract, project, market and client. A survey was planned and used by the investigators to collect the data nationally. The survey was sent to 450 construction companies in Australia and 81 companies responded to the survey. The results were obtained using descriptive and Inferential text analysis. This analysis showed the disparity of 26 bid or no bid factors in spite of the difference in the mean scores and rankings in the four factors namely strength or weakness, bidding condition, number of bidders and contract payment terms. The recognized bid or no bid factors rise the importance of present decision-making practices and this plays an important role in the decision-making principles in future of the construction companies and in which the decision makers need to study the upcoming different opportunities.

According to Oyeyipo et al., (2016) [6] a structured questionnaire survey was used as the important tool to collect data from the different respondents. A total of hundred (100) samples were drawn from among many construction contractors of the Lagos state.

Fifty (50) contractors responded and returned the questionnaire which represented a response rate of 50%. Mean score, percentage, frequency and Spearman correlation was used in analyzing the collected data. Results obtained indicated that capital availability, material availability and client's financial capability are the important factors that a contractor considers when taking no bid or bid decision. This research also tells that contractors must increase their reputation in the construction industry by obtaining the technological capabilities and also competencies as these qualities are considered as important in evaluating the competitiveness of contractors and also act as primary and important indicators of successful tendering in construction projects. This paper also highlights the important factors considered by the contractors and compares them with similar studies conducted in different countries. The reliability of the results and its applicability may be verified in any other country by increasing the size of sample.

According to B. Narkhede et al., (2016) [7] a study was conducted out to find the factors that influences bid or no-bid decisions for an EPC project. The study was carried out using various methods such as oral questions, sampling, data collection and data analysis. Bid or no-bid decision process framework consisting of three stages is explained to deliver a structured method to the contractors to select the useful and advantageous projects from the different options available. The following results obtained stated that orderly procedure is cited for factors influencing bid decisions are- swot analysis, message learned from past projects and evaluation of the bid. Contractors can be successful in bidding by using the above steps. It can be concluded that the main intention of the research is to deliver the primary procedures with finest rehearsal and also tools that help the EPC contractor to take decisions related to bid in the environment which is competitive. Since the study was conducted on a single company by analyzing its past bid data and opinions of employees from same organization was carried out, the generalization of strategy may further require validation of framework with past bid data from other construction industries.

According to J. Kiran Kumar., (2016) [8] a research was conducted to study the different factors which influences the bid or no-bid decisions of various projects related to construction in India. The study was carried out using various steps namely questionnaire survey, mean and standard Deviations. Questionnaire survey was carried out among different contractors of south India and the response obtained were properly documented. This questionnaire survey was also designed to rank the obtained factors on the basis of its importance and the factors which had high ranks were studied in detail giving the contractor a strong and solid base for making decisions related to bid or no-bid. The results obtained stated that the Important factors that contribute a bid or no bid decision are availability of qualified material

suppliers, familiarity and experience of the firm with similar kind of work, project size, monetary capability of the company and total value of the bid. The less important factors responsible for the bid decisions are desire for qualified contractors to bid and win for the project and need for continuity in employment. It can be concluded that this research helps to understand the process of bidding and it also guides the contractors in selecting successful projects, keeping the construction sector improving and healthy and adds to the growth of economy both nationally and globally. This study on Indian construction contractors shows importance of past experience, availability of adequate finance and quality suppliers as important factors to be addressed during bid decision. The results vary with reference to the similar study conducted on small and medium sizes contractors from Surat, India. This may be due to selection of varied range of type of construction project.

According to A. O. Olatunji et al., (2017) [9] a research was conducted out to find the important factors contributing the choice of indigenous contractors to not to bid or to bid in Nigerian construction industry. In this study, an analysis was directed on the data that was received through the questionnaires responded by sixty-four engineering management employees of the important construction companies in Nigeria. This research recognized 41 important decision features frequently considered by the indigenous contractors of Nigeria earlier to the process of bidding. Mean score was found for each of these factors respectively. Principal component analysis was utilized to indicate the factors which were the most important ones. International contractors and local contractors can adopt these important factors mentioned in this research for handling their structures for interorganizational partnerships.

According to M. Alsaedi et al., (2019) [10] a study was carried out to find the critical and important factors that disturb the bidding decisions of the contractors in Saudi Arabia. Questionnaire survey consisting of thirty-one different factors was circulated among second, third and first-grade contractors. The factors were then assigned under different headings namely market, project, Contractor Characteristics and owner/designer/labor characteristics. The responses collected were 67. Relative importance index (RII) and median techniques has been utilized to rank the important factors. Depending on the replies established, the six vital factors were "size of the job", "type of the job", "company's strength in the industry", "designer/design quality", "rate of return" and "project cash flow". The factors that had less importance were "job start time" and also "labor environment". It can be concluded that the decision for a contractor to bid is influenced by the uncertainty of the cost. The study was conducted on all the three grades of contractors. The results showed highest agreement of results between second and first grade contractors whereas it was less between third and second grade contractors, According to Y.

Tan et al., (2010) [11] a research was carried out to find the competition strategies of the different contractors in the construction industry of Hong Kong. A questionnaire survey was conducted among 320 contractors from February 2007 to May 2007 in order to find out the effectiveness and also the frequency of competitive strategies of bidding and 42 replies were received.

Based on previous reviews, 13 competition strategies such as management innovation (S3), bid which is low (S1), high technology (S2), partnership (S5), joint ventures (S4), claim (S7), public relationships (S6), technology transfer (S9), warranty (S8), sharing of risk (S11), architectural design (S10), accountability and social responsibility (S13) and sustainable practice (S12). The study can be summarized into three groups 1) Bid which is low (S1), high technology (S2) and innovations of the management (S3), 2) Policies for winning the contracts are almost same amongst the various types of projects and 3) Respondents are arranged into three groups depending on the frequency of using strategies for different projects. The two important applications of this study were helping contractors form good strategies in bidding and help contractors find possible opportunities in foreign and local markets.

According to M. Jarkas et al., (2013) [12] a study was carried out to recognize and to rank the important factors recognized to affect the bidding mark-up decisions amongst the local contractors involved in bidding of projects related to construction. The effect of 40 different identified factors from previous literature studies based on the factors disturbing the bid mark-up decisions and also the inputs from experts of different resident construction industry. "Relative Importance Index" was utilized to rank the factors established. The results revealed that the primary factors that influence the bid mark-up decisions were project size, identity and the type of employer, technical specifications, identity and number of competitors, earlier experience with the employer, earlier experience in same kind of projects, work load, complexity involved in the design, tendering situation and quality of the design. It is also suggested to determine and find the influence of the factors that were most important.

According to Yan et al., (2018) [13] a study was carried out to look into the important factors which influence the process of group decision making in construction related projects. The study utilized in-depth interviews, past literature reviews and questionnaire survey for data collection. Literature review involved two steps 1) research on factors relating to organizational, group and individual level that impacts bid decision making. 2) Selecting the factors that influences the group decision creation but not being restricted only towards the group decision creation. 18 factors were selected from this process. Second step involved face to face interview with 32 senior and middle managers of Chinese construction industry and each managers company used the process of group decision making. A questionnaire survey was then conducted among 203 Chinese contractors to find the importance of these recognized factors and support the further analysis of the factors and five-point Likert scale was used to find the respondent's opinions. The results obtained indicate 14 important factors and among that "team decision preference"

and "risk perception" were considered as the most important. 20 factors can further be classified into 1) empowerment and development 2) consensus reaching 3) risk awareness 4) strategic goals and values and 5) learning and collaboration. It can be concluded that this study deepens the understanding of the factors that are important during group bidding decision making process. The result recommends adaption of group bid decision in order to minimize errors in decision making by involving group members who are well aware of the company's strategies and goals.

According to Deng et al., (2013) [14] A study was made to empirically investigate the various factors framing the competitiveness of the construction industry of china. 34 important factors were listed based on past literatures and to analyze how much these different factors affect the competitiveness; questionnaire survey was conducted. The data collected were then analyzed using the SPSS software and the factors were ranked out of which qualified professionals, skilled workers, management bidding strategy, work ethics and steady growth of home market were ranked at the top. A cluster analysis was then conducted to group these different factors that result in forming clusters headed as supply chain management, stable home market, qualified professionals, corporate management practices, satisfactory business environment and migrant workers. This study helps the contractors to consider these different factors during the process of preparation of bid, which not only increases competitiveness among contractors but also permits the contractors to improve their strategies for bidding.

A study carried out by H. Setiawan et al., (2015) [15] using semi structured interviews to know the key factors for aggressiveness of the contractor which was analyzed using thematic analysis revealed the most important factors are maintaining good relationship, functioning like a problem solver for different clients, being changed associated to competitors, upholding confidence among clients and concern about quality are the main key factors. This paper helps to understand the competitive aggressiveness of Indonesian contractors in a simple way. Contractors ability to form an appropriate strategy and this allows them to be aggressive in competition and also to win new projects in the long run.

According to S. Deep et al., (2017) [16] a research was carried out to study to different factors that affects the performance of a contractor in lowest bid award construction projects. The study was carried out using various steps such as questionnaire survey, overall index and relative importance index. Two kinds of questionnaires were developed for two different groups namely, public organizations and construction organizations. Architects, contractors, consultants, sub-contractors and engineers were in the first group. State/central government departments and public agencies departments were included in the second group. The responses obtained from questionnaire survey were analyzed to identify the practices and trends in procurement and bid in central government owned construction projects and state government of UP.

The factors contributing to delay according to the Rank were as follows, Contractor related Factors with EARII- 64.62, project related factors with EARII- 63.82, laborer related factors with EARII- 62.46, design related factors with EARII- 62.28, owner related factor with EARII- 60.28, consultant related factors with EARII- 60.26, external related factors with EARII- 60.25, equipment related factors with EARII- 59.61, material related factors with EARII- 59.31.

This research helps to know the reason for decrease in the efficiency of small-scale contractors in Indian Construction scenario. Project Management techniques should be familiarized among such contractors to improve the efficiency. This research also emphasizes the review of contractor's percentage margin in case of lowest bid proposals.

According to D. Darbar and J. Pitroda (2018) [17] the failure and success of any construction company depends mainly on bidding decision. Time plays an important factor in the decision making. Construction industry in India accounts to 3% in overall GDP (Gross Domestic Product) growth and future improvement depends on the successful completion of the tendered projects. Questionnaire survey was constructed and distributed among medium and small-scale contractors in Surat, Gujarat to determine the factors affecting the contractors bidding decision. The respondents were requested to rank these factors on 5-point Likert scale and Relative Importance Index (RII) was used to find the importance of 39 factors obtained from the questionnaire survey. It can be concluded from this study in Surat that the main factors contributing the bidding decisions were size of project, availability of labor, equipment and number of employees in the firm. The results obtained can be used to develop a decision process which is systematic that will be helpful to firm's having limited resources.

According to Chen et al., (2014) [18] a study was carried out to find the relationship among different decision maker's risk propensity and perception and their bid decision creation in construction projects and also the various factors that influence risk propensity and perception. Based on past literature review, four different hypotheses were proposed. Questionnaire surveys were distributed among employees of Chinese construction contracting companies having knowledge related to bidding and 134 responses were obtained for the survey. An analysis known as multivariate statistical analysis using a software called SPSS was used to analyze the data obtained. Analysis showed that risk perception had an undesirable impact on bid decision making whereas risk propensity showed a constructive contribution and magnitude, likelihood of gain and loss have sufficient effects on risk perception and likelihood plays a very vital role. The frequency of usage of identified strategy may vary with construction industry from various countries. However, the strategies adapted to win across various projects within a country more or less remains the same.

III. DECISION SUPPORT SYSTEMS (DSS) FOR TAKING BID DECISIONS

According to Abotaleb et al., (2017) [19] a study was carried out to find out the importance of bidding mark-up

decision using Bayesian Analytic framework. A three-stage methodology was used. 1) a structured procedure was established to fit the past historical data of the competitors into beneficial prior density functions of Bayesian while taking into consideration the stochastic variability of estimates related to cost. 2) the researchers developed stochastic likelihood functions through the recent observations. 3) the researchers created the posterior distributions from which the expected probability of winning and profit can be calculated. Results stated that the Bayesian statistics involved in the research helps to draw proper statistical inferences even in circumstances of incomplete data and dynamic behaviors of the competitors, thus tackling the two very important weak areas of the previous models. This model was applied in two case studies obtained from the past literature with different scenarios to show its use and to demonstrate the effect of various factors on the resulting optimum mark-up. It can be concluded that recent strategies of bidding related to competitors play an important role in forecasting the future strategies.

According to Biruk et al., (2017) [20] a study was carried out to study the main tools that facilitate bidding process for construction contractors. The methodology involves three steps namely deciding whether to bid or not, estimating the over-all price involved and breaking down this entire price into objects of Bill of Quantities. Deciding whether to bid or not makes use of past literatures, estimating the total price involves interpolation between highest justifiable and lowest acceptable price based on the attractiveness of contractor and breaking down the total price makes use of a linear programming model. The results show that the model provides a justified price for bid along with the breakdown, keeping the proportions amongst unit prices of particular items in bill of quantities. This research doesn't focus on trade-off amid price and likelihood of winning but it mainly focuses on the most sensible price under specific project situations.

Chisala (2017) [21] This research has established a simple additive weighted scoring model to produce importance weights of 75 bid factors from a structured-questionnaire survey study of contractor in the Malawi Contract Construction market for 'bid' or 'no-bid' decision behavior by means of the linearly weighted least-squares scheme. The performance of the proposed model showed an accuracy of 86% in comparison with the actual decision when tested with 35 real-life bidding situations. The author depicted his aim of providing an actual tool for decision-makers in the construction industry for creation of appropriate but quality and dependable decisions using current model and market-specific data to offer an agenda to build computerized bidding decision-support web portals. The proposed model's limitations were due to minor sample sizes taken for both the main questionnaire survey and model test study survey. Further, this being a market-specific application requires similar studies for each prospective market. In addition, the results found out considering the dynamic difficulty and players in the industry.

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The presented conclusions must be considered as an idea and investigative modelling of the real-world phenomena.

According to Shofiyah et al., (2018) [22] a Neuro-fuzzy model was formed to complement the ANN and Fuzzy approach weakness. Their developed model consists of two stages bid no-bid and bid price employing “If and Then” approach having 5 layers.

Top five important influenced factors are taken as input each having 5 categories from the data collected which are trained and validated to yield the lowest bid by comparing the generated output with actual tender winning bidder price.

Authors achieved 100% accuracy in bid no-bid decision and 94.48% in bid price decision having 3.125 rules combined with a winning probability of 75%. They suggested factor analysis is more appropriate for the selection of influencing factor since they considered five major factors in ANN model development. Application of MATLAB software in developing Neuro-fuzzy model will enhance the model’s applicability in industry due to its ease in operation It can also be noted that identified factors influencing bid or no-bid decisions are similar to that of previous studies.

IV. RESULTS OF COLLATION OF PAST RESEARCHES ON BID DECISION IN CONSTRUCTION

A. Factors contributing to decision on bid or no-bid in construction

Author, Year & Country of Research	Topic of Research	Methodology & Results	Remarks on Research findings
A. Enshassi, S. Mohamad, A. El Karriri, 2010, Palestine	Factors affecting the bid/no-bid decision in the Palestinian construction industry	<p>The methodology involved was Postal Questionnaire and Relative Importance Index (RII). 78 factors were grouped under 4 major heads such as factors related to ‘contractor’, ‘client’, ‘contract & project’ and ‘external environment’. The responses were obtained from Client, consultant and contractor0s. One-way ANOVA was carried out to ensure the absence of difference in opinion obtained in the response.</p> <p>The following results were obtained:</p> <ol style="list-style-type: none"> 1) Under the contractor’s characteristics, “Financial Capabilities of the Contractors” was rated as the top factor by client, consultants and contractors with average RII value of 0.894. 2) ‘Financial Capabilities of client’ was rated as top factor under the client characteristics with RII value of 0.921. 3) Financial values of the project having RII 0.858 was ranked as top factor under ‘contract & project’ characteristics 4) The availability of raw materials having RII 0.921 was the important factor under ‘external environment’ factor influencing bid decisions. 	<p>Financial factors were considered as most important by the Palestinian construction industry.</p> <p>Also, it was recommended that, the process of awarding the bid should give due considerations to staff competencies (emphasis to their past experience), technical capabilities and financial capabilities of the contractors have to be given in addition to the lowest financial proposals.</p>
A. M. Jarkas, S. A. Mubarak and C. Y. Kadri, 2013, Qatar	Critical Factors Determining Bid/No Bid Decisions of Contractors in Qatar	<p>The methodology involved was structured questionnaire survey and RII.</p> <p>The following findings can be noted for this research:</p> <p>43 factors contributing to bid decisions of contractors in Qatar were found be highest for the employer related factors followed by contactor related and project related.</p> <ol style="list-style-type: none"> 1) Earlier practice with the employer has been rated as 87.39%, 2) Need for work and Current workload with RII of 86.30 and 86.09 3) Earlier experience in like projects with a RII of 84.57% 	<p>Similar to the above study critical factors for Qatar industry was also found to be related to employer or client characteristics. In addition to knowing about the financial capability of the client, the experience of working with same client will add a value to decide whether to bid or not. This was further reinforced by the factors like whether there is a need for the work? what is the current work load of the organization? i.e., whether the organization has any idle resources? etc.</p>
Author, Year & Country of Research	Topic of Research	Methodology & Results	Remarks on Research findings

<p>S. Dey, B. A. M. Das and Dr. A. Dewangan, 2018, India</p>	<p>Assessment of Competitive Bidding Strategy Scenarios in the Construction Industry of India</p>	<p>The methodology involved was Relative Importance Index, Descriptive statistics, Chi-square test of independence, Spearman correlation.</p> <p>The results obtained were:</p> <ol style="list-style-type: none"> 1) Various factors related to Client, Contractors influencing the bid decisions are determined 2) Various factors influencing mark-up decisions are also determined 3) It can be concluded that number of successful bids in different project size and mark-up size are independent to each other 	<p>A study can be carried out to determine the various factors that influences the bidding decisions of international and domestic construction firms in India.</p> <p>The study can also be conducted to verify the similarity between client and contractor's perception.</p>
<p>D. Darbar and J. Pitroda, 2018, Surat, Gujarat, India</p>	<p>Critical review on factors affecting bid/ no bid decision making process of contractors in Surat</p>	<p>The methodology involved was Questionnaire survey & Relative Importance Index on small and medium sized contractors.</p> <p>The following results were obtained:</p> <p>It was asked to rank each of the factors on five-point Likert Scale and RII was used to determine the importance of 39 factors obtained in the questionnaire survey. It was concluded that top factors influencing bid decisions were-</p> <ol style="list-style-type: none"> 1) Availability of labour and equipment 2) Project size & Number of employees in the firm & Profit <p>The less important factors were</p> <ol style="list-style-type: none"> 1) Tax 2) Bidding price & method of tendering 3) General Overheard and duration of Tendering 	<p>The results obtained from this study on small and medium sized contracting organizations of Surat, India can be used to develop a systematic decision process that could be helpful to firm's having limited resources.</p> <p>However, the past studies also showed, the importance given by the large construction firms significantly vary than compared to small and medium contractors. The importance is generally influenced by their organizational goals and targets. Hence, there is need to conduct a separate study for the large construction contractors.</p>
<p>N. Chileshe and M. Ghasabe, 2015, Australia</p>	<p>Critical factors influencing the bid/no bid decision in the Australian construction industry</p>	<p>The methodology involved was National survey & Descriptive and Inferential text analysis of 81 contractors from small and medium construction contractors.</p> <p>The following results were obtained:</p> <p>This analysis showed the difference of 26 bid factors in spite of the difference in the mean scores and rankings in the subsequent four factors</p> <ol style="list-style-type: none"> 1) Condition of bidding 2) Strength or weakness 3) Payment terms of contractor 4) Number of bidders <p>As per the total sample, the extremely rated four factors were</p> <ol style="list-style-type: none"> 1) Financial competence of client 2) Risk involved in project 3) Upcoming benefits and profit in project 4) Number of bidders <p>The minimum ranked factors were:</p> <ol style="list-style-type: none"> 1) Financial situation of the contractor 2) Duration of Project 3) Contractors material availability 	<p>The study results confirm the previous studies by rating the client's financial capability as the factor with highest importance.</p> <p>Contractors financial situation was rated as lowest important factor. This may be due to the fact that, the responses were the perception of contractors only. The same factor was one among the top in Palestinian construction industry study were opinion was collected from client and consultant also.</p> <p>However, the findings of the study can be utilized and interpreted for small construction industries of Australia since, major chunk of the responses were obtained from the small contractors.</p>
<p>O. O. Oyeyipo, K. T. Odusami, R. A. Ojelabi and A. O. Afolabi, 2016, Nigeria</p>	<p>Factors affecting contractors bidding decisions for construction projects in Nigeria</p>	<p>The methodology involved was Structured Questionnaire Survey, Frequency, Percentage, Mean score & Spearman correlation.</p> <p>The following results were obtained:</p> <ol style="list-style-type: none"> 1) Financial capability of clients with mean 4.56 2) Availability of capital with mean 4.53 3) Availability of material with mean 4.39 <p>The important factors contractor considers while taking bid the decision.</p> <p>The study exposes that the competition (figure and individuality of competitors) with mean 3.42 does not have important contribution on contractors bid decisions</p>	<p>The top three identified by this study confirms with the results of Palestinian and Australian small contracting organisations. The reliability of the results and its applicability may be verified in any other country by increasing the size of sample.</p>

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<p>O. A. Olatunji, O. I. Aje and S. Makanjuola, 2017, Nigeria</p>	<p>Bid or No-Bid decision factors of Indigenous contractors' in Nigeria</p>	<p>The methodology involved was Questionnaire Survey, Mean Score & Principal component analysis. The study mainly compared the results of descriptive and inferential statistics.</p> <p>The following results were obtained:</p> <p>Analysis was done on information from questionnaire surveys obtained from sixty-four engineering management employees of important construction firms. The research recognized 41 important decision factors frequently looked by Nigerian indigenous contractor's earlier to bid.</p> <ol style="list-style-type: none"> 1) The post hoc result factors comprise- 2) Consultants clarity of project conditions 3) Earlier association amongst the proposing bidder and client 4) Accessibility of additional projects at the period of bidding 5) Technical difficulty of the project under deliberation 6) Prequalification necessities 	<p>This study of indigenous construction contractors from Nigeria showed varied results between analysis of descriptive and inferential statistics. Only 2 among the top 11 factors identified by the respondents were found significant in the inferential statistic study. This emphasises the importance of inferential statistics in understanding factors contributing to bid decision.</p>
<p>Author, Year & Country of Research</p>	<p>Topic of Research</p>	<p>Methodology & Results</p>	<p>Remarks on Research findings</p>
<p>J. K. Kumar, 2016, India</p>	<p>A study on key factors influencing bid/no bid decisions for different construction projects in India</p>	<p>The methodology involved was Questionnaire Survey.</p> <p>The study on construction contractors from India found the following important factors for bid decisions-</p> <ol style="list-style-type: none"> 1) Experience and familiarity of firm with similar kind of work 2) Financial situation of the company 3) Availability of Qualified material suppliers 4) Total bid value & project size <p>The least important factors being-</p> <ol style="list-style-type: none"> 1) Need for continuity in employment 2) Competent contractors to bid and win the project 	<p>This study on Indian construction contractors shows importance of past experience, availability of adequate finance and quality suppliers as important factors to be addressed during bid decision. The results vary with reference to the similar study conducted on small and medium sizes contractors from Surat, India. This may be due to selection of varied range of type of construction project.</p>
<p>B. Ratekar, V. Girme and Dr. B. Narkhede, 2016, Mumbai, India</p>	<p>Basic guidelines for bid/No bid decision making in the EPC projects.</p>	<p>The methodology involved was Questionnaire Survey and Sampling which was conducted on a single organisation with participation of 25 employees from various departments.</p> <p>The study provided guidelines for bid decision in the case of EPC projects which is as follows</p> <ol style="list-style-type: none"> 1) Inform the concern team and list down the factors that affect the bid/no-bid decision 2) Message studied from previous projects 3) SWOT investigation 4) Bid valuation <p>Contractors can be successful in bidding by using the above steps.</p>	<p>The intention of the research is to deliver the primary strategies with top rehearsal and tools that aids the EPC contractor to take decision on bid in this extremely competitive environment.</p> <p>Since the study was conducted on a single company by analysing its past bid data and opinions of employees from same organisation was carried out, the generalisation of strategy may further require validation of framework with past bid data from other construction industries.</p>
<p>S. Deep, M. B. Khan, S. Ahmad and A. Saeed, 2017, Uttar Pradesh, India</p>	<p>A study of various factors affecting contractor's performance in lowest bid award construction projects</p>	<p>The methodology involved was Questionnaire survey, Overall Index & Relative Importance Index.</p> <p>The Primary difficulties that were encountered was</p> <ol style="list-style-type: none"> 1) Equipment and Material Shortage <p>The Secondary difficulties that were encountered was</p> <ol style="list-style-type: none"> 1) Cash and Manpower <p>The tertiary difficulties that were encountered was</p> <ol style="list-style-type: none"> 1) Supervision and design/drawing <p>The factors contributing to delay according to the Rank were as follows</p> <ol style="list-style-type: none"> 1) Contractor related Factors with EARII- 64.62 2) Project related factors with EARII- 63.82 3) Labourer related factors with EARII- 62.46 4) Design & owner related factors with EARII- 62.28 & 60.28 5) Consultant related factors with EARII- 60.26 6) External related factors with EARII- 60.25 7) Equipment & material related factors with EARII- 59.61 8) Material related factors with EARII- 59.31 	<p>This research helps to know the reason for decrease in the efficiency of small-scale contractors in Indian Construction scenario. Project Management techniques should be familiarised among such contractors to improve the efficiency.</p> <p>This research also emphasises the review of contractor's percentage margin in case of lowest bid proposals. This helps in understanding contractor's ability to complete the project with minimum cash flow congestion problems during execution.</p>

<p>M. Alsaedi, S. Assaf, M. A. Hassanian and A. Abdallah, 2019, Saudi Arabia</p>	<p>Factors Affecting Contractors' Bidding Decisions for Construction Projects in Saudi Arabia</p>	<p>The methodology involved was Questionnaire Survey & Relative Importance Index. This study was conducted in the eastern province of Saudi Arabia.</p> <p>The very significant factors were</p> <ol style="list-style-type: none"> 1) Job size with RII- 78.8 2) Type of the job with RII- 77.3 3) Company's strength in the industry with RII- 77 4) Designer/design quality with RII-73.1 5) Rate of return with RII- 73.1 6) Project cash flow with RII- 73.1 & Competition with RII- 72.5 <p>The least important factors were</p> <ol style="list-style-type: none"> 1) Job start time with RII- 60.6 2) Labour environment with RII- 57.3 	<p>This research would improve the information of contractors to know the factors influencing bid decisions in numerous ways. Moreover, this will aid them in choosing the suitable project, resulting in better performance and gaining good profits.</p> <p>The study was conducted on all the three grades of contractors. The results showed highest agreement of results between second and first grade contractors whereas it was less between third and second grade contractors.</p>
<p>P. Yan, J. Liu and M. Skitmore, 2018, China</p>	<p>Individual, Group and Organizational Factors Affecting Group Bidding Decisions for Construction Projects</p>	<p>The methodology involved was Questionnaire Survey, Interview & Non probability Sampling. A questionnaire survey of 203 Chinese international contractors were carried out and the following results showed 14 important factors and among those-</p> <ol style="list-style-type: none"> 1) Team decision preference 2) Risk perception were the most important <p>The 20 factors obtained from the past studies can be grouped under five headings namely-</p> <ol style="list-style-type: none"> 1) Empowerment and development 2) Consensus reaching 3) Risk awareness 4) Strategic goals and values 5) Learning and collaboration 	<p>This research particularly focuses on the benefits of group bid decisions when compared to bid decisions taken by only head of the organisation. The result recommends adaption of group bid decision in order to minimize errors in decision making by involving group members who are well aware of the company's strategies and goals.</p>
<p>Author, Year & Country of Research</p>	<p>Topic of Research</p>	<p>Methodology & Results</p>	<p>Remarks on Research findings</p>
<p>F. Deng, G. Liu and Z. Jin, 2013, China</p>	<p>Factors formulating competitiveness of Chinese construction industry: Empirical investigation</p>	<p>The methodology involved was Questionnaire survey, Cluster Analysis & SPSS Software.</p> <p>The following results were obtained which showed that-</p> <ol style="list-style-type: none"> 1) Qualified professionals & skilled workers 2) Management bidding strategy 3) Work ethics 4) Steady growth of home market was ranked at the top <p>Cluster analysis was conducted to rank these factors as</p> <ol style="list-style-type: none"> 1) Supply chain management 2) Stable home market 3) Qualified professionals & migrant workers 4) Corporate management practices 5) Satisfactory business environment 	<p>Since the study was conducted in Chinese construction industries and also from the past studies it can be noted that the market context and institutional environment varies significantly among different countries, similar studies in different construction industries will enhance the understanding of competitiveness of construction industry in general.</p>
<p>H Setiawan, B. Erdogan, and S. O. Ogunlana, 2015, Indonesia</p>	<p>Competitive aggressiveness of contractors: A study of Indonesia</p>	<p>The methodology involved was Semi structured Interview & Thematic analysis with bottom up approach. After the interview of 19 top managers of contracting companies in Indonesia, the following results were obtained:</p> <ol style="list-style-type: none"> 1) Performing as client's problem solver 2) Being different compared to the competitors 3) Constructing and preserving client's confidence 4) Keeping respectable relation with clients & worry about quality 	<p>The study conducted on Indonesian construction industry experts reveals the pro-active behaviour expected from a contractor in order to give an aggressive competition compared to their competitors.</p>

Collation of Decision Support System (DSS) models used for Bid Decisions in Construction Industry

Y. Tan, L. Shen and C. Langston, 2010, Hong Kong	Contractor's Competition Strategies in Bidding: Hong Kong Study	The following results were obtained after analysing 13 competition strategies named S1 to S13 1) Bid which is low (S1), high technology (S2) and innovations of the management (S3) 2) Policies for winning the contracts are almost same amongst the various types of projects 3) Respondents are arranged into three groups depending on the frequency of using strategies for different projects	In this research an emphasis on key strategies responsible for improving the chances of winning a bid was discussed. This provides an insight to local contractors and clients to understand competition strategies in bidding. The frequency of usage of identified strategy may vary with construction industry from various countries. However, the strategies adapted to win across various projects within a country more or less remains the same.
Author, Year & Country of Research	Topic of Research	Methodology & Results	Remarks on Research findings
A. M. Jarkas, 2013, Kuwait	Primary factors influencing bid mark-up size of general contractors in Kuwait	The methodology involved was Relative Importance Index. The following results were obtained after ranking 40 factors contributing to contractors bid mark-up decisions were as follows 1) Project size 2) Identity and the type of employer 3) Technical specifications 4) Identity and number of competitors 5) Earlier experience with the employer 6) Earlier experience in same kind of projects 7) Work load & Complexity involved in the design 8) Tendering situation and quality of the design	The study recommended the determination of the relationship between the factors explored, especially the ones that are considered very important as a future scope of study. Also, it can be noted that most of the identified important factors for mark-up decisions from this study of Kuwait construction industry is similar to that of important factors influencing bid decisions in Saudi Arabian construction industry.
Y. Q. Chen, S. J. Zhang, L. S. Liu and J. Hu, 2014, China	Risk perception and propensity in bid/no bid decision-making of construction projects	The methodology involved was Questionnaire Survey, Multivariate statistical analysis & SPSS Software. The following results were obtained after testing four hypothesis using SPSS software 1) Risk Perception has negative influence whereas risk propensity has positive influence on bid decision making 2) Magnitude and Probability of profit or loss have influence on risk perception	This study can be conducted by increasing the sample size, involving people from different backgrounds and people having different experiences to improve the measure of probability. This research provides a new dimension to risk perception and risk propensity in bid decision making.

B. Decision support systems (DSS) for taking bid decisions

Author, Year & Country of Research	Topic of Research	Methodology & Results	Remarks on Research findings
I. S. Abotaleb and I. H. El-adaway, 2017, USA	Construction Bidding Mark-up Estimation using a Multistage Decision Theory Approach	The methodology involved was Establishment of the structured procedure to fit the past data, Development of stochastic likelihood functions and Creation of the posterior distributions to calculate profit. Results stated that the Bayesian statistics involved in the research helps to draw proper statistical inferences even in circumstances of incomplete data and dynamic behaviours of the competitors, thus tackling the two very important weak areas of the previous models.	This model can be tested on many case studies and the process can be made automated using a software tool to use the model. This model can incorporate competitors recent bidding strategies to predict the competitor's behaviour in future projects. This understanding about competitor's behaviour will improve the probability of winning of the contract as well as fixing up of optimum bidding mark-up.
Author, Year & Country of Research	Topic of Research	Methodology & Results	Remarks on Research findings

<p>M. L. Chisala, 2017, Malawi</p>	<p>Quantitative Bid or No-Bid Decision-Support Model for Contractors</p>	<p>The methodology involved was Questionnaire Survey, linearly weighted least-squares scheme & Simple additive weighted scoring model.</p> <p>Results indicated that the performance of the proposed model showed an accuracy of 86% in comparison with the actual decision when tested with 35 real-life bidding situations.</p>	<p>Since the study is restricted to Malawi construction industry also the validity and accuracy of prediction of the model was tested based on 35 live projects, further studies can focus on adopting similar procedure of development of model with a greater number of validating and testing samples.</p>
<p>S. Biruk, P. Jaśkowski and A. Czarnigowska, 2017, Poland</p>	<p>Modelling contractor's bidding decision</p>	<p>The methodology involved was Deciding whether to bid or not, Estimating the over-all price involved & breaking down this entire price into objects of bill of quantities. Linear programming model was also used in this study.</p> <p>The results show that the model provides a justified price for bid along with the breakdown, keeping the proportions amongst piece prices of specific items in bill of quantities.</p>	<p>This study can be conducted by involving more factors that influence the capacities to deliver and please the client and the chance of winning the bid.</p> <p>This paper highlights the importance of bid or no-bid decision in fixing up the mark-up model.</p>
<p>Q. Shofiyah, T.J. W. Adi and M. Syaain, 2018, Indonesia</p>	<p>Estimated Model for Contractor using Neuro-Fuzzy</p>	<p>The methodology involved was Questionnaire Survey, Relative Importance Index & Neuro-fuzzy.</p> <p>The following results have been obtained:</p> <ol style="list-style-type: none"> 1) Expected profits, project size & financial ability of contractor 2) Historical data of profit/loss on similar projects 3) Experience on similar projects are the major factors influencing bid decisions <p>Authors achieved 100% accuracy in bid no-bid decision and 94.48% in bid price decision having 3.125 rules combined with a winning probability of 75%.</p>	<p>Application of MATLAB software in developing Neuro-fuzzy model will enhance the model's applicability in industry due to its ease in operation.</p> <p>It can also be noted that identified factors influencing bid or no-bid decisions are similar to that of previous studies.</p>

V. DISCUSSION

The above table describes various researches carried out across the world to identify important factors contributing to bid decisions and various Decision Support Models developed to aid the bid decision. It can be noted that the major factors such as client's financial capability, contractor's financial capability, past experience of the contractors in similar projects etc., were considered across the globe. However, its priority of consideration varied from country to country as well as between various grades of contracting organizations. Further, it can be learnt from the past researches that the strategies adopted by medium and large contractors is almost the same and consistent. Whereas, the small contracting organization adopts different strategies depending upon the bidding situation, financial position and capability of organization. This complex and dynamic nature of bid decision making demands a robust decision support system which can be adopted universally at least in a construction industry within a country. Moreover, the bid decision is more of subjective in nature. So, addressing this with only quantitative models which considers past bid data, recently applied strategy, assumption of linear nature etc., may not be sufficient to predict the dynamic phenomenon. This strongly suggests the need for development of a Qualitative model to take care of subjective decision-making situation.

VI. CONCLUSION

Many surveys have been carried out in various countries with the intention of identifying the important bid decision factors show that, there is significant difference in priority of factors from country to country. The review of the past literatures resulted in identifying different potential factors contributing contractor's bid decisions. By using methods such as Relative Importance Index, Thematic analysis - Project characteristics, Material availability, Client characteristics, Contractor characteristics, Past experience characteristics, Company characteristics and Financial characteristics were the most important factors influencing the bid decisions. The RII values of identified factors range from 0.53 to 0.917. As the range is narrow, and the lowest value is more than 0.5, it can be said that the measured factors have high impact on the bid decision. The knowledge about the RII further strengthens the weightage and importance to be given to the several factors while deciding bid. These listed factors help the new contractors during bid decision making which aids them to keep away from the risk of exclusion of few factors which are necessary for bid decision making. Statistical models,

Artificial Neural Network (ANN), Artificial Intelligence-Based Models, Multi-Attribute Decision-Making Models, Neuro-fuzzy model, Bayesian analytic framework and Regression techniques were used to construct the mark-up determination models.

The main and important differences in the above quantitative models were the number of factors considered and the methods that were incorporated to build the model. For instance, using Neuro-fuzzy model an accuracy of 100% was achieved in bid decision and 94.48% in bid price decision. Using the Neuro-fuzzy technique in determining the bid decision and exploring the options of getting higher accuracy results appears to be valuable in resolving the problem of the bid decision. In addition to quantitative models, qualitative models facilitate the contractors to go for bid decisions with flexibility and confidence due to its subjective nature.

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