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A COMPREHENSIVE BID/NO-BID DECISION MAKING FRAMEWORK FOR CONSTRUCTION COMPANIES*

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Abstract– Bidding is a strategic decision that helps contractor firms to survive. Traditionally, bidding behaviors are highly unstructured in construction companies. This paper discusses the issues involved in evaluating a tender to assist the managers of a firm in making reliable and sound decisions. The emphasis of the work is on developing a logical decision making framework that covers organizational, environmental, risky and financial considerations.

The model takes advantage of well-known decision making methods such as the analytical hierarchy process and the simple additive weighting. The model's input would be the linguistic description of each project's value with respect to the decision criteria, and the output would be the value of each project proposed to decision makers considering its correlation with existing projects. By means of a case study, the model has been implemented. The proposed decision making model is found to yield substantially improved solutions when large size contractors are concerned.

Keywords– Bid/no-bid, correlation, framework, contractor firm

1. INTRODUCTION

In general, projects are awarded to contractors via tenders. The preparation of a bidding package is time-consuming and costly. Contractors pay attention to the benefits of bidding versus the human resources and the bidding costs such as the documents prices and the required bonds. Thus, it is important to develop a bidding strategy framework for construction companies.

The bidding process involves bid/no-bid and bid price (or mark-up) decisions. Bid/no-bid decision is associated with uncertainty and complexity because of subjective considerations such as the nature of the project. Since the contractors bidding behaviors are influenced by numerous factors related to both the specific features of the project and dynamically changed situations, bidding decision problems are highly unstructured. Typically, contractors make these decisions based on their common sense or primary rules of thumb. This may or may not lead to sub-optimal decisions. This is why many researchers have been involved in developing bidding strategy models.

Moselhi has categorized bidding strategy models into three categories: 1) models based on probability theory which requires quantitative data; 2) models based on decision analysis which are based on decision making models, and 3) models based on knowledge-based expert systems [1].

This paper intends to apply the decision analysis approach. Decision making methodologies have been categorized into multi attribute decision making (MADM) and multi objective decision making (MODM). Because of the characteristics of the problem, MADM approach is concerned in the current

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research. MADM refers to making a selection among some courses of action in the presence of multiple and usually conflicting attributes [2].

Most of the previous authors focused on crisp MADM methodologies, but bid/no-bid decisions require applying vague and incomplete information. The conventional methods for bid/no-bid decisions are inadequate for dealing with the imprecise or vague nature of linguistic assessment. Bid/no-bid decision making contains a mixture of fuzzy and crisp data. To overcome this difficulty, fuzzy multi-criteria decision-making methods are used in the framework. The aim of this study is to use fuzzy analytic hierarchy, simple additive weighting, and heuristic ideas in a logical order.

The main concerns of this paper are:

1- To facilitate decision making for contractor firms by proposing a multi-stage practical conceptual model.
2- To identify, categorize and determine critical bid/no-bid factors, particularly based on Iranian contractors' interests.
3- To adopt an integration of fuzzy set theory approach and multi-criteria decision making to make bid/no-bid decisions.
4- To take care of new projects correlation with living projects of the company in decision making as a separate category of criteria.
5- To present a multi-stage bid/no-bid decision making process

2. LITERATURE SURVEY

Ahmad and Minkarah, Shash and Abdul-hadi, Hegazy and Moselhi, and Ting and Mills were some of the bid/no-bid decision making contributors prior to 1996 [3-6]. This paper is focused on giving state of the art main existing models, particularly regarding the models and key factors concerned.

Dozzi et al. presented 24 factors in environmental, company, and project categories for mark-up decisions [7]. Shash has attended subcontractors bidding practices including the invitation to bid, bid submission, pre and post-bid negotiations [8]. Other researchers have surveyed bidding practices of Canadian construction contractors. Factors influencing bidding decisions and the probability of winning were ranked, and 11 categories of factors influencing the fuzzy bidding margin size determination model were identified [9].

35 factors that characterize the bidding decisions were identified and ranked according to their importance to contractors operating in Syria. A simple parametric solution for the 'bid/no bid' decision is reported in this paper [10].

Wong et al. applies Fuzzy Stochastic Dominance (FSD) as a new tool for multi-attribute decision making for project selection [11]. Chua and Li collected a list of determining factors from the results of past researches and opinions of six experienced practitioners in competitive bidding, and then proposed their AHP approach based on a model using 51 factors in hierarchical order [12].

Dulaimi and Shan have shown that the size of the contractor would have a significant bearing on factors that would influence the bid mark-up decision. Forty factors were identified and a survey was conducted in Singapore. The factors were categorized in project characteristics, company characteristics, bidding situation, economic environment, and project documentation [13].

A method for bid/no-bid decision-making using fuzzy linguistic has been devised by Lin and Chen. In this approach, a natural framework for representation and manipulation in a situation with incomplete data and vague environments is constituted. Managers assess criteria using a set of linguistic terms. Term values are then approximated by their membership functions, and by using fuzzy logic arithmetic [14, 15].

Egemen and Mohamed made efforts to uncover key factors influencing bid/no bid and mark-up size in Northern Cyprus and Turkish construction markets [16].

Using fuzzy set theory in the MADM problem was first done in 1970. Fuzzy Multiple-Attribute Decision Making (FMADM) can cover the uncertainty and vague nature of construction problems properly. Using FMADM has recently become more common in construction industry researches. Ziara et al. used fuzzy AHP for modeling a system that implemented infrastructure priority projects [17]. Huang et al. utilized fuzzy AHP for selection of R&D projects [18]. Zhang et al. used fuzzy AHP method for risk assessment of joint venture construction projects in China [19]. Other researchers like Chao et al., Carr et al., and Han and Dikeman used fuzzy set theory in their researches [20-22]. Despite the major advantages of fuzzy set theory and MADM methods in the construction industry, there are few researches in the area, especially regarding the bid/no-bid problem. The authors attempted to overcome the deficiencies of previous models by proposing a localized conceptual model.

3. PROPOSED BID/NO-BID DECISION MAKING FRAMEWORK

The "decision theory" approach suggests certain factors in terms of which a project proposal might be evaluated, and derives a scoring model whereby a rating on an empirical scale is made for each factor considered, and these ratings are combined either by multiplication or as a weighted sum, or according to heuristic rules to derive a numerical score for each project. So the selected projects are those with the highest scores, the number of projects selected for bidding being determined by the constraint of the total available resources.

This research proposes a multi stage bid/no-bid decision making process:

Step 1) Identify the decision making criteria

For the current study, a comprehensive survey of the factors influencing the bidding decision has been done by the authors and the result was a list of 103 factors extracted from previous academic works; also, the opinions of experts with an interviewing approach were considered.

Step 2) Screen the criteria and decompose the problem to hierarchical order

In order to avoid overlaps and cover all the issues, 29 factors have been selected through the primary 103 factors by discussions of 5 experts in the bidding area. The decisions were made on consensus.

Miller theory says that seven plus or minus two represents the greatest amount of information an observer can give about an object on the basis of an absolute judgment [23]. Therefore, the experts were asked to decompose the factors into 5, 7 or 9 clusters. Their endeavors ended in 5 categories of criteria consisting of 25 sub criteria, which is shown in Table 1.

Step 3) Pair-wise comparison of decision criteria

The analytic hierarchy process (AHP) is one of the most widely used multiple-criteria decision-making approaches. AHP has been used in civil engineering by many researchers such as Mustafa and Al-Bahar, Shen et al., Alhazmi and McCaffer, Carlos and Costa, and Ziara et al., and Huang et al. [24-27, 17, and 18]. This paper applies the pair-wise comparison for weighting each decision making criterion in step 3 and step 4.

Step 4) Consistency analysis and finalizing each criterion's weight

One of the major capabilities of AHP is that it can measure the consistency of a decision maker [28]. Consistency Index (C.I.) and Consistency Ratio (C.R.) are two indices commonly used to verify the consistency of pair-wise comparisons. The C.I. is the variance in errors occurring in pair-wise comparisons and is computed according to Eq. (1). The C.R. is the ratio of C.I. and the random consistency index (R.I.) obtained by Eq. (2). The R.I. represents the average consistency index over numerous random entries of the same order reciprocal matrices. If C.R≤0.1, the estimate is accepted; otherwise, a new comparison matrix is solicited until C.R≤0.1 (Saaty, 1990).

$$C.I. = \frac{\overline{\lambda}_{\max} - n}{n - 1} \tag{1}$$

$$C.R. = \frac{C.I.}{R.I.} \tag{2}$$

In this step, the weights are assessed from the consistency analysis point of view. Final inconsistency is equal to 0.06, which is less than 0.10. Therefore, the weights are acceptable.

Table 1. Bid/no-bid criteria hierarchy

Criteria	Subcriteria	reference
Organizational consideration in bidding	Company workload and need for work	• Egemen & Mohamed, 2007 • Chua and Li,2000 • Chua et.al, 2001 • Paul and Carr, 2005 • Alsugair, 1999 • Shash and Abdul_handi, 1992
	Project prestige, public exposure and its strategic fitness to policy	
	Project client, supervisor, and other stakeholders characteristics	
	Competitors' approach and the probability of winning the bid	
	Availability of time and human resource for tendering	
Project characteristics	Project complexity and company's familiarity with this kind of work	• Egemen & Mohamed, 2007 • Fayek,1998 • Cagno et.al, 2001 • Chua and Li,2000 • Moselhi et.al, 1993 • Alsugair, 1999 • Shash and Abdul_handi, 1992
	Duration of the project and its schedule feasibility	
	Site conditions (Accessibility and Space for Work)	
	The availability of the needed material, equipment, sub-contractors and suppliers	
	Constructability of the work method and technical documents	
Risk	Having no resource price fluctuation and general inflation effects	• Han & Dikeman, 2001 • Egemen & Mohamed, 2007 • Chua and Li,2000 • Dikeman et.al, 2007 • Al Salman, 2004 • Kwak and Laplace, 2005 • Zhang and Zou, 2007
	Disbursing payment without delays	
	Suitable climate and weather and geographical conditions	
	Stabling laws, standards, and requirements	
	Lack of probable claims and their effects	
Financial considerations	Expected benefit/loss and its rate of return	• Egemen & Mohamed, 2007 • Cagno et.al, 2001 • Chua and Li,2000 • Chua et.al, 2001 • Moselhi et.al, 1993 • Alsugair, 1999
	Project cash flow and payment conditions	
	Tendering bond size, bidding document price	
	Client's financial capability and its payment policy	
	The value of project advanced payment and its maximum required cash	
Projects Synergy, correlation and Portfolio effects	Project distance from existing projects and facilities of the company	• Egemen & Mohamed, 2007 • Chua and Li,2000 • Veragara, 1997
	The similarity of the project type and size to other company projects	
	Project resource similarity and its influence on existing projects performance	
	The similarity of client or supervisor to the existing projects	
	Project cash flow interrelation with existing projects	

Step 5) Define fuzzy membership functions for linguistic variables

There are several ways for deriving Membership Functions (MFs) like experimental data, perception of linguistic terms and the simulation of reality. In this paper, triangular MFs for representing linguistic terms were used. Table 2 shows the triangular membership functions representing linguistic terms.

Table 2. Corresponding fuzzy MFs to linguistic terms

Linguistic terms	Triangular Fuzzy MF
Very High (VH)	(7.5 , 10 , 10)
High (H)	(5 , 7.5 , 10)
Medium (M)	(2.5 , 5 , 7.5)
Low (L)	(0 , 2.5 , 5)
Very Low (VL)	(0 , 0 , 2.5)

Step 6) Determine fuzzy simple additive weighting (FSAW) utility function

In Fuzzy SAW (FSAW), the values of each alternative regarding each attribute can be expressed in linguistic terms (Eq. (3)). Here, fuzzy arithmetic is applied for computation. The trade-offs among all attributes are compensatory. This means that the estimation of each attribute is totally independent on the others and this does guarantee the final score to be more reliable. The application of fuzzy sets allows the MADM method to be flexible in accordance with vague information. The research develops a fuzzy MADM formulation for every project scoring.

$$U = \sum_{i=1}^{n} w_i r_{ij} \tag{3}$$

Where w_i is the weight of attribute i and r_{ij} is the rate of alternative j th with respect to attribute i th.

Step 7) Consider the characteristics of new and current projects

Potential projects and also living ones would be identified, and their characteristics would be evaluated in this step.

Step 8) Decision makers estimate of the criteria

Potential users include managers who have the authority to make a decision; the technicians, and key bidding staff of the company who can influence the strategy of the company can make the appropriate estimates of projects in the linguistic terms defined. This represents the project value regarding each sub-criterion.

Step 9) Fuzzy representation of the decision makers' estimation

This research defines five linguistic terms "Very High", "High", "Medium", "Low", "Very Low" that should be transferred to mathematical language in Membership Function (MF) shape. Linguistic terms will be fuzzified by the fuzzy numbers defined in step 4. (Table 2)

Step 10) Importing the weights, and estimates of projects to the software

To implement the model a software program was developed. The weights of each criterion and the value of each alternative would be inserted in the graphical user interface. After running the program, a fuzzy membership function of the final score of each project would be shown.

Step 11) Evaluating and ranking the projects

This paper uses a defuzzifying approach to determine every project's score. A crisp number is defined which is named Defuzzified Index of Competence (DIC). DIC is a normalized score out of 100. This index is calculated automatically by the program and based on fuzzy arithmetic approaches.

Step 12) Select appropriate projects for bidding

Based on the approach mentioned in step 11, the projects are ranked, and the best selected for bidding. In this step, an appropriate candidate project will be selected. Then bid documents would be prepared and the mark-up decision and further bidding operation will be done.

4. CASE STUDY

In this section, a bid/no-bid evaluation for an international large size Iranian construction company is cited to demonstrate the application of the proposed method. The company's name and its projects are presented in symbolic terms. The company has been presented by "TCC", existing projects are abbreviated in "EPn" and potentially new projects are shown by "NPn".

TCC Construction Company was established in 1975 in Tehran, Iran. Since then, it has executed numerous domestic/international projects. President of Deputy Strategic Planning and Control, representing the Iranian government, has ranked TCC as a "Grade A" contractor which makes it automatically prequalified for implementing any large public project in the construction field in Iran valuing more than 20 million US$.

TCC has acquired vast and diversified knowledge and experience in many construction domains, especially in roads, highways, infrastructures, railways, airports, urban and wastewater treatment construction projects.

The managers of the company are interested in diversifying TCC activities in dam construction, industrial complexes, and metro construction disciplines. In line with its new long term policy, TCC has decided to expand its international activities, especially in the booming market of the UAE. The company is eager to add new large scale, diversified, special projects to its portfolio of projects. Currently, TCC is engaged in 4 different projects, which are:

"EP1" which is a 50 km highway in Asalouyeh (south of Iran); its client is the Ministry of Petroleum; a 31 million US$ project; 80 percent complete;

"EP2" which is an infrastructure project near Isfahan (center of Iran); its client is Isfahan Municipality, a 15 million US$ project; 40 percent complete;

"EP3" which is a wastewater treatment project in Tehran (capital of Iran); its client is the Ministry of Power; a 42 million US$ project; 20 percent complete;

"EP4" which is an airport terminal project in Mashhad (northeast of Iran); its client is the Ministry of Road and Transportation; a 12 million US$ project; 90 percent complete;

There are three simultaneous projects in the market. Because of some considerations such as limited resources, TCC wants to bid on only one of the following tenders:

"NP1" which is a 56 Km railway way near Shiraz (south of Iran); its client is the Ministry of Road and Transportation; a 49 million US$ project; comparatively well supported by the client; equipment resources are available; good site conditions; particular work as of its tunnel and bridges; relatively mild climate;

"NP2" which is an infrastructure project near Dubai, UAE; its client is Dubai Municipality; a 24 million US$ project; well supported by the client; equipment resources are available; restricted site conditions; a simple work regarding technical issues; arid climate;

"NP3" which is a dam project in Lorestan (west of Iran); its client is the Ministry of Power; a 43 million US$ project; delayed payment is predicted; limited local resources are available; site accessibility is difficult; a different work for TCC; cold with heavy snowfall climate;

The proposed model was applied for the case. In order to implement the program, the experts were asked to describe their opinion about every project value versus corresponding criteria. Weights of each criterion and the value of every project (project degree) are imported to the program. Figure 1 shows one of the outputs of the software package that shows results for NP1.

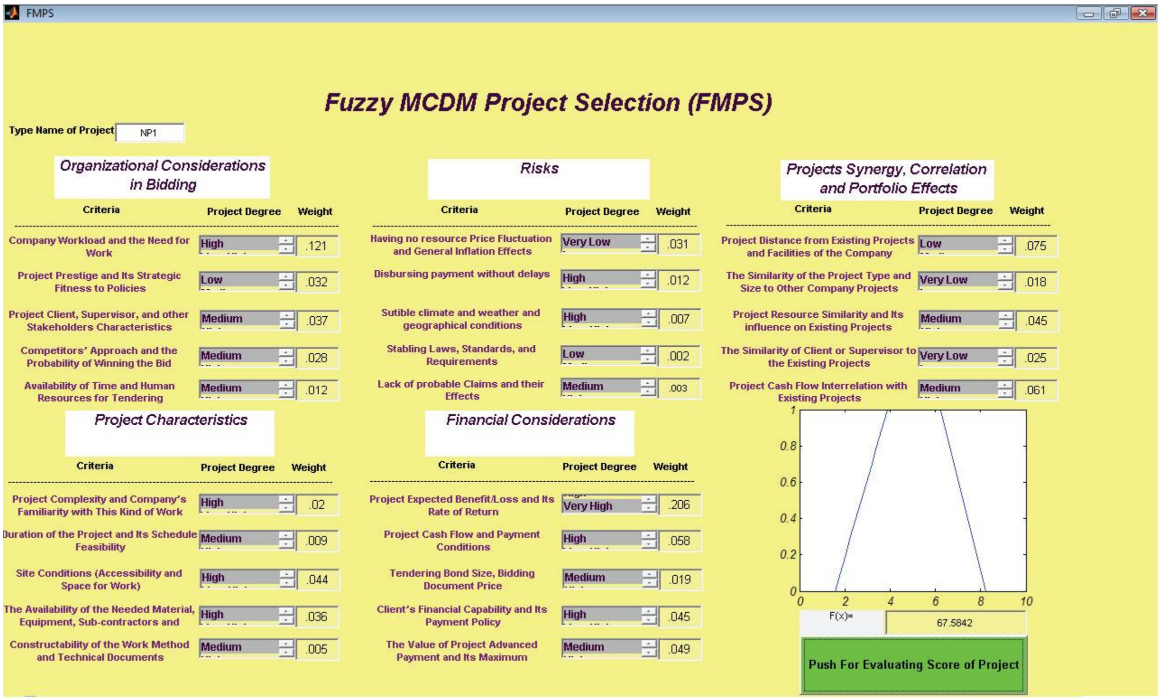

Fig. 1. FMPS package results for project NP1

Finally, the projects were ranked based on their fuzzy membership functions. Table 3 represents the DIC's of the projects. The managers of the company selected 60 as a minimum required DIC for a project to be selected. Therefore, NP1 and NP2 passed the threshold. After further investigations the company decided to bid on NP2.

Table 3. Projects' final ranking and their DICs

Ranking	Project	
1	NP2	72.80%
2	NP1	67.58%
3	NP3	54.06%

5. CONCLUSION

This paper reports the outcomes of a bid/no-bid decision making model for contractors in the field of construction industry. The model attempted to cover the shortcomings of previous models, particularly regarding comprehensiveness. Fuzzy sets theory has been successfully applied and the users showed satisfaction in the results.

The case study demonstrates the model strength and user-friendliness features of the developed software, and exhibits its capabilities for any practical application. As described, NP2 was finally selected by the model for bidding. This matches the eagerness of the company to expand its international activities, especially in the booming market of the UAE, demonstrating the validation of the model in practical application.

It is proposed that the research be continued by considering the influence of a company's diversification policy on its project selection decision in future academic works.

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