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BID/NO BID DECISION USING FUZZY RISK ASSESSMENT

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Abstract: Bid / No-Bid decisions for large number of projects for construction companies can be cumbersome, tedious and complex task due to the uncertainty, uniqueness of each project and numerous internal and external factors. Contractors' reputation is generated through the successful completion of projects contractors execute each year. The goal of construction companies is to keep their projects profitable while being executed in line with contractors' ambition to be an industry leader in sustainability. The profitability of contractors depends on the success of their projects which can be achieved only with an appropriate bid/no bid decision system.

This paper introduces a comprehensive two-stage bidding assessment framework for the contractors. The proposed approach helps evaluating the bid/no bid decision and removing any ambiguity that may be associated with the decision process. A competency group scored heat map model to exclude projects with an unattractive opportunity/risk profile as much as possible and as early as possible during the selection phase and a project risk model using fuzzy logic to decide whether to bid or not to bid. The proposed framework is expected to help contractors improving the bidding strategy and ensuring that an efficient bidding processes is in place, as well as relevant resources.

1 INTRODUCTION

The decision to bid or not to bid for a given project should be carefully considered to balancing the opportunity, against a realistic evaluation of the likelihood of success. Successful contractors follow repeatable processes to manage the bid life cycle. Contractors use checklists and frameworks to document, track and communicate their strategy and monitor progress towards consistent and well-defined milestones. Research in the area of competitive bidding strategy has been in progress since mid-1950s. Numerous models have been developed, some of which are designed specifically for construction industry. These models are classified into three categories: Bid/no bid models; Mark up models; and Bid/no bid and mark up models.

The usual practice is to make bid decisions on the basis of intuition, derived from a mixture of gut feeling, experience and guesses (Ahmad 1990). One characteristic of the construction business is that risks and opportunities are not symmetrical. Unlike industries with standardized products, it is difficult to develop realistic models that capture the complexity and uncertainty of full construction contract bidding situation. There is still a need for the development of new tools to help decision makers and improve the selection process for bidders. Many techniques have been used to model the process of making competitive tendering decisions. These techniques include expected monetary value (Hosny and Elhakeem 2012), expected utility value (Hassanein and Hakam 1996), multi-criteria decision analysis (Ahmad and

Minkarah 1988), regression analysis (Broemser 1969), expert systems (Egemen and Mohamed 2007), neural networks (Hegazy and Moselhi 1994; Parvar 2000), and fuzzy set theory (Ravanshadnia et al. 2011; Leśniak and Plebankiewicz 2013; Marzouk and Mohamed 2018) and neuro-fuzzy (Wanous 2003; Polat et al. 2014).

2 PRE-TENDER RISK MODEL

To strengthen risk management practices, contractors established department for risk management which introduces procedures and tools to enable risks to be identified, avoided, mitigated and managed. The performance of one large project in the construction sector has the potential to significantly influence the performance of the contractor as a whole. The aim of risk management is to support the operating units in reducing the number of projects which do not go according to plan and to do so constantly and continuously. Contractors exclude projects with an unattractive opportunity/risk profile as much as possible and as early as possible during the selection phase. The risk management unit analyses the causes behind positive and negative outcomes of construction projects in order to drive valuable lessons learned especially regarding the contractors' business goal and particularly on earning trends, liquidity and reputation. As the contractors' monitoring and controlling risk, they are looking for new opportunities in order to secure the long existence in the market. The pre-tender risk model consists of two consecutive modules as presented in the next subsections.

2.1 Scored Heat Map – Contractor Group Competency Assessment

The first analysis for new project opportunity is based on a Scored Heat Map which consists of a matrix of the contractor group's core competence. The proposed scored heat map – contractor group competency assessment is an integration of heat map and bid/no bid check list evaluating the criteria specified in Table 1. To proceed to the tender phase, a project must be checked against the Scored Heat Map, which identifies core competencies for the project. This analysis determines whether the project has the correct workforce and knowledge of the local market, and whether the contract form, client and consultant profiles provide the prerequisites for a positive end result.

The Scored Heat Map – Contractor group Competency Assessment consisting of the following steps:

1- Assigning a threshold upper (A %) and lower (B %) range for contractor group competency, given from the company policy depending on yearly targets.
2- Contract size (amount), given from company policy and contractor classification.
3- Answering the questions done by decision maker at tender phase.
4- Assigning weights to criteria done by decision maker at tender phase and depend on the project information as each project is unique.

The map can be easily adapted to any other companies with advantage to change the weights and upper and lower range for group competency. This model depends first on the criteria coloring then the summation weighted score for the all criteria where:

1- If the business compliance criteria are less than (B %) then criteria is red therefore the decision is "No Bid" regarding the other criteria color.
2- If the total scored heat map for all criteria is less than (B %) then decision is "No Bid".
3- If two or more criteria color red then decision is "No Bid".
4- If only three criteria color are yellow (range less than (A %) and greater than or equal to (B %)) then decision is "Purchase Tender Document plus project risk model.
5- If the four criteria color are green (range greater than (A %)) then decision is "Purchase Tender Document + project risk model.

Table 1: Description of scored heat map – contractor group competency assessment attributes

Model	Criteria	Definition	Factors (Sub-criteria)	Group Competency Scale			
	INPUTS:			A%>	A% - B%>=	B%<	
Scored Heat Map - Contractor Group Competency Assessment	Business Compliance	Set standards in business ethics. Analysis to determines whether the project within scope & budget.	- Corruption - Project Scope - Project Budget	Score for each criteria + Color System			
	Diversity	The region and segment the company operates.	- Geographic Diversity - Segment Diversity - Urbanization	Score for each criteria + Color System			
	Client	Knowledge about the clients is a prerequisite for becoming a proactive market maker. Listening to the client to generates new business opportunities.	- Reputation - Requirement - Payment Habit - Financial Capacity	Score for each criteria + Color System			
	Consultant	Knowledge of the Specifications	- The Reputation "Fair Determination" - The Level/Degree/Amount of work Performed	Score for each criteria + Color System			
	OUTPUTS:						Decision
	Competency Assessment	**Criteria weighted according to group policy. Summation scored with coloring system.**	**- Scored Heat Map (SHM) = ∑Criteria x Weights**	SHM >A% and	Project complies to Four criteria (Green)		Purchase Tender Documents + Project Risk Model
				SHM = A% - B% and	Project complies to Three criteria (Yellow)		Purchase Tender Documents + Project Risk Model
				SHM < B% or	- Business Compliance = Red - Project complies to Two or less criteria (Red)		No Bid

2.2 Project Risk Model – Bid/No Bid

The risk profile of the construction and project development business differs from other industry. Risks and opportunities exist in the projects that are executed every year, which are generally unique as regards design, function or location. Presence in different markets and a variety of types of projects and contracts as well as client categories provide risk diversification. As there are few opportunities for repetition, there is little standardization of the construction work which therefore is highly dependent on the skills of employees. Well-implemented identification and management of risks and opportunities during tender preparation lay the ground work for successful projects and avoid potential negative impact on the attainment of qualitative or quantitative business goals, particularly the company's earnings, liquidity and reputation. At the planning stage, all potential risks that could inhibit the project's success are identified by the project team. Those risks that are most likely to occur are highlighted via metrics such as past experience regarding the likelihood of occurrence, historical data, key performance index and lessons learned.

To ensure a systematic and uniform assessment of risks and opportunities, the project risk model is developed using fuzzy logic covering uncertainties and complexities in construction tender phase. The Project Risk Model is used to identify and manage potential risks using ten input variables which are financial, human resource, legal, technical, investment, market, procurement, environmental, IT and political and one output which is project risk. In order to simplify the risk prioritization and assessment approach, it was reorganized into categories and factors (sub-criteria). To help ensure that companies works toward improving risk assessment and create a uniform approach to risk and opportunity, a fuzzy logic model is developed.

3 PROJECT RISK HIERARCHY EVALUATION

In order to simplify the risk prioritization and assessment approach, it was reorganized into categories and factors (sub-criteria). A mechanism to aggregate risks from the lower level to the higher level to calculate the risk for each category is developed. This model evaluates projects on a continuous basis from preparation of tenders to completion of the project.

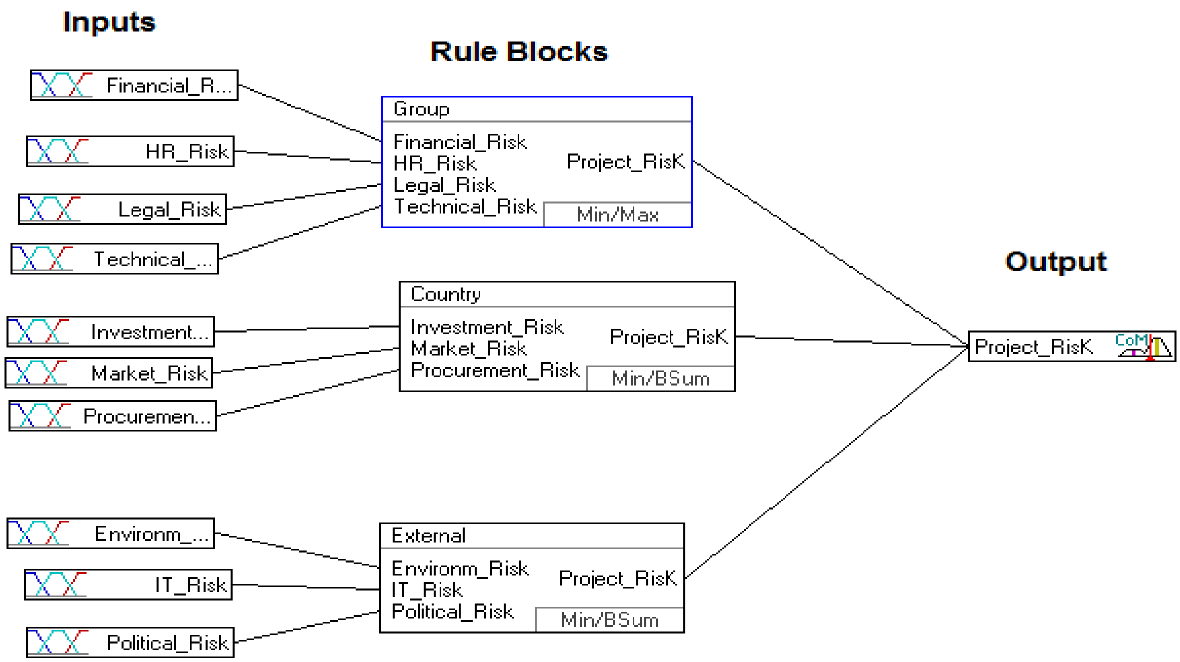

Figure1: Project risk model structure

The factors (sub-criteria) are determined and grouped under each of the ten risk categories. The hierarchy, however, can be easily adapted to any other contractor's structure and new risk category and factors (sub-criteria) can be added depending on the project, industry and market characteristics. To allow consistency among the risk categories, a risk index of 25 points is used divided into four expressions which are low, medium, high and very high. The (RI) ranges from 0 to 25 where (RI) of 0 implies for low risk with Very Low probability and Very Low severity, and (RI) of 25 implies high risk with Very High probability and Very High severity. Risk is defined as an event that occurs with a certain probability in combination with a consequence.

$[1]\ \text{Risk Index} = \text{Probability of risk} \times \text{Risk Severity (Threat)}$

Figure 2 shows a complete project risk hierarchy evaluation for a project under analysis which follows the following procedure:

1- Assign weights to risk categories factors. Weights represent if this factor is applicable for the project under evaluation and the risk category break down. The weights are assigned per project as each project is unique.
2- Enter risk severity and probability to every factor including weights.
3- Locate the risk index (RI) for every factor according to the probability –severity matrix.
4- Number ONE is placed to every factor that has RI in step 3.
5- The **Total risk index for each risk category** is aggregated and calculated from the factor (sub-criteria) list along their weights by using Equation [2]

   [2] $\mathrm{RI_j} = \sum_{i=1}^{n} \mathrm{W_i} \times \mathrm{RI_{ij}}$

   Where $\mathrm{RI_i}$= Risk Index for Criteria Risk (j);
   $\mathrm{W_i}$ = Weight for sub-criteria (factor) where $\sum_{i=1}^{n} \mathrm{W_i} = 1$
   $\mathrm{RI_{ij}}$ = Risk Index for sub-criteria (factor) Risk (i) for the main risk (j).
6- The output for the project hierarchy evaluation is **TEN TOTAL RISK INDICES** considered the inputs for fuzzy project risk model as explained in the next section.

Project Risk Hierarchy Evaluation

Risk Index (RI): Low 0–5 | Medium 6–14 | High 15–21 | Very High 22–25

Please Insert Weights, Risk Severity & Probability in each sub-criteria (factor)

Criteria/ Sub-Criteria	Weight	RS	P	Risk Index (RI)	Total RI
1. Financial Risk	**1**	**RS**	**P**		**2.00**
1.1 Interest rate risk	0.1	M	VL	6	0.6
1.2 Foreign exchange risk	0.1	VL	VL	1	0.1
1.3 Credit risks related to Financial assets	0.1	VL	VL	1	0.1
1.4 Credit Risk if a counterparty does not fulfill its contractual payment obligation	0.2	VL	VL	1	0.2
1.5 Liquidity risk	0.3	VL	L	2	0.6
1.6 Payment flow risk	0.2	VL	L	2	0.4
2. Human Resource Risk	**1**	**RS**	**P**		**10.00**
2.1 Skilled & experience labour, Management & Supervision shortages	0.25	M	M	13	3.25
2.2 Fluctuation in work force	0.25	M	VL	6	1.5
2.3 Lack of confidence in work force	0.25	VL	VH	11	2.75
2.4 Labour law risk	0.25	H	VL	10	2.5
3. Legal Risk	**1**	**RS**	**P**		**10.00**
3.1 Contract Type	0.2	L	H	12	2.4
3.2 Joint Ventures	0.2	L	M	8	1.6
3.3 Tender documents & conditions	0.2	M	L	9	1.8
3.4 Legal Claims (Time, Cost or both)	0.2	VL	VH	11	2.2
3.5 Change Orders	0.2	H	VL	10	2
3.6 Tax law risk		H	VL	10	0
4. Technical Risk	**1**	**RS**	**P**		**6.00**
4.1 Inaccurate of cost estimation	0.2	H	VL	10	2
4.2 Lack Resources needed - materials		M	VL	6	0
4.3 Lack Resources needed - equipment		M	VL	6	0
4.4 Vagueness of design	0.2	L	VL	3	0.6
4.5 The rigidity of specifications	0.2	L	L	5	1
4.6 Technological difficulty of the project being beyond the capability of the firm	0.1	L	M	8	0.8
4.7 Safety hazard	0.2	L	L	5	1
4.8 Hard Site location and accessibility	0.1	M	VL	6	0.6
5. Investment Risk	**1**	**RS**	**P**		**2.00**
5.1 Share holding in companies	1	VL	L	2	**2**
6. Market Risk	**1**	**RS**	**P**		**6.00**
6.1 Economic Growth (GDP)	0.25	M	VL	6	1.5
6.2 No. of Competitors	0.25	M	VL	6	1.5
6.3 Inflation	0.25	M	VL	6	1.5
6.4 Escalation	0.25	M	VL	6	1.5
7. Procurement Risk	**1**	**RS**	**P**		**10.00**
7.1 Technical selection for subcontractors & suppliers	0.4	H	VL	10	4
7.2 Commercial selection for subcontractors & suppliers	0.3	VH	VL	15	4.5
7.3 % of subcontracted works	0.3	L	L	5	1.5
8. Environmental Risk	**0**	**RS**	**P**		**0.00**
8.1 Weather conditions	0	VL	VL	1	0
8.2 No Compliance with Environmental law	0				
9. IT Risk	**1**	**RS**	**P**		**1.00**
9.1 Cybercrime	1	VL	VL	1	**1**
10. Political Risk	**1**	**RS**	**P**		**1.00**
10.1 Construction Interruptions	1	VL	VL	1	1
10.2 Foreign ownership restrictions	0				
10.3 Dispossession	0				

Figure2: Project risk hierarchy evaluation

4 FUZZY LOGIC SYSTEM

Fuzzy logic is presented as a Decision Support System (DSS) for the bidding process. Developing the fuzzy logic system involves the following steps:

Step 1 Definition of inputs and output variables. Figure 3displays the inputs **(risk hierarchy evaluation outputs)** and output values of all system variables. The output for the model is called Project Risk.

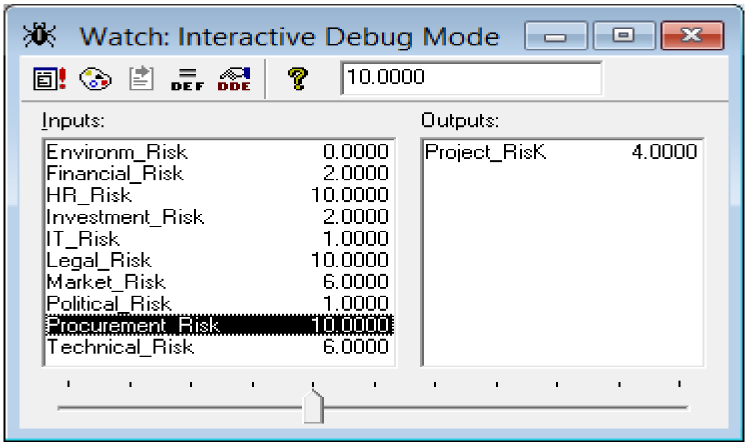

Figure 3: Interactive Debug Model

Step 2 Defining membership functions (MF). The MF associated with the inputs and output is defined. The degree of membership to which a crisp value belongs to a linguistic value (term) of the linguistic variable is determined. This membership degree is represented by a value in the range of 0 - 1. A membership degree of 0.0 means no membership at all; a degree of 1.0 means full membership. The main decisions in this step are:

a- Number of linguistic terms for each variable. For all input variables four linguistic terms are used which are low, medium, high and very high. Four linguistic terms are used for the output variables which are low, medium, high and very high.

b- Triangular MF is used for all inputs and output variables. The range for all input and output variables are from 0 to 25. The upper and lower range for each variable is determined. Figure 4 shows "Technical Risk" as an input variable and "Project Risk" as an output variable.

Step 3 Definition of the fuzzy rules. Developing fuzzy rule generation approach is very useful to the knowledge acquisition phase of artificial expert systems. The procedure to generate fuzzy rules consists of historical projects, expert (project manager, risk business manager) brainstorming and artificial neural network from historical projects to generate more rules.

Step 4 Defuzzification. At the end of the fuzzy inference, the results for the Project Risk is given as a linguistic term and translated into a real value. This step is called defuzzification. The relation between linguistic term and corresponding real values is always given by the membership function definitions. As fuzzy logic mimics the human decision and evaluation process, a good defuzzification method should also approximate this approach. Most defuzzification methods use a two-step approach. In the first step, a "rule block" value is computed against the equivalent linguistic term. In the second step, the "best compromise" crisp value for the linguistic result is computed. Figure 5 illustrates this step.

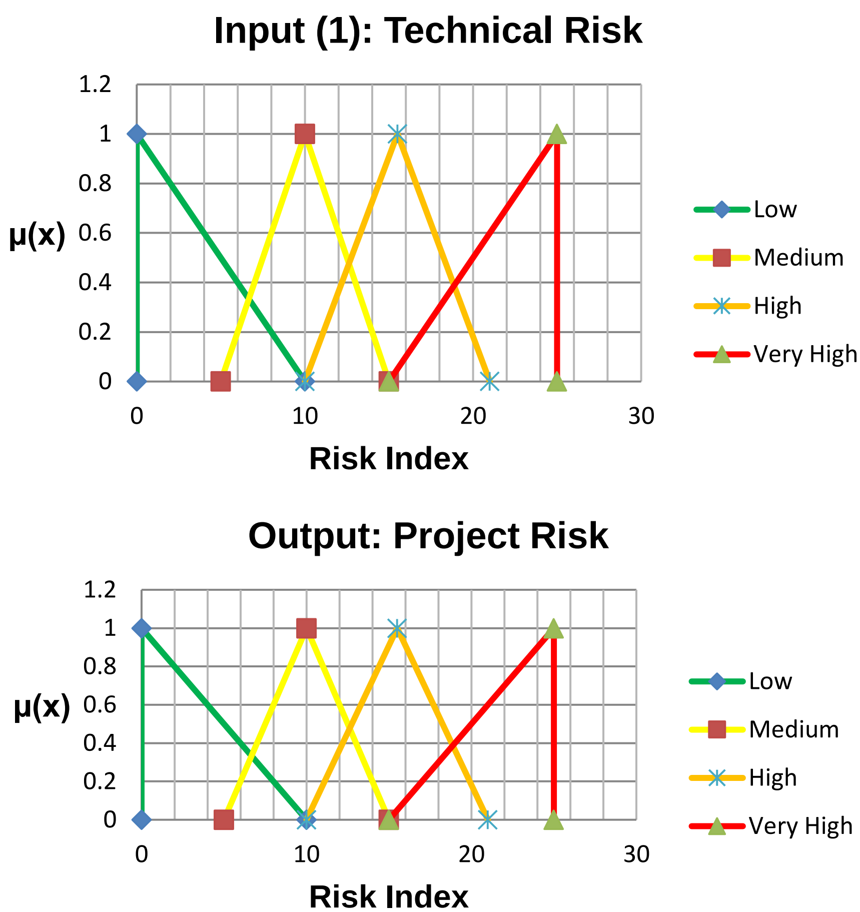

Figure 4: Membership functions for input and output variables

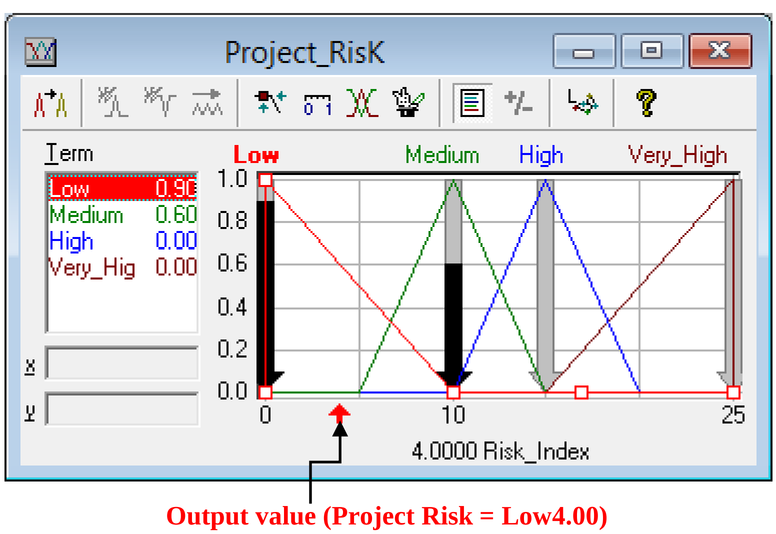

Figure 5: Defuzzification with center of maximum

5 IMPLEMENTATION: PROJECT RISK MODEL

Project risk model is a fuzzy logic system which is used as a decision support system (DSS) for bidding in the construction. Construction companies are focused on continuously improving all aspects of the bid/no bid decision. In some projects further analysis should be done to reach the best decision where contractors long terms targets such as business model, earning, order backlog, acquisition, dividend and development. To support policy-makers, an efficient decision strategic risk system that uses the System Dynamic simulation technique to analyze the impact of various policy scenarios and optimize policy decisions.

There are four linguistic terms for the "project risk" which are:

1- "Low" then the decision is "BID".
2- "Medium" then the decision is another analysis has to be performed using the **"Strategic Risk System Dynamic Model".**
3- "High" then the decision is another analysis has to be performed using the **"Strategic Risk System Dynamic Model".**
4- "Very high" which means that the project is most likely to negatively impact the profit and liquidity, decision **"NO BID"**

6 SUMMARY AND CONCLUSIONS

This paper presents the development of decision support system for bid/no bid model using two consecutive approaches to reach the final decision: 1) competency – scored heat map; 2) project risk model using fuzzy logic system. The first approach is essential to go to the next model. Fuzzy logic model is used as decision support system for the bidding process which includes risks and factors governing the decision are identified in a hierarchy risk assessment. The hierarchy evaluation is developed to elicit risk knowledge pertaining to the tender preparation practices for the contractors. A dynamic weighting for risk factors is used depending on the project characteristics. The project risk model output direct the user to the next step whether to bid, go to the strategic model or reject the project.

7 REFERENCE

Ahmad, I. 1990. Decision-support system for modeling bid/no-bid decision problem. *Journal of Construction Engineering and Management* 116 (4):595-608.

Ahmad, I., and Minkarah, I. 1988. Questionnaire survey on bidding in construction. *Journal of Management in Engineering* 4 (3):229-243.

Broemser, G. M. (1969). Competitive bidding in the construction industry. *(PhD Thesis), Graduate School of Business, Stanford University*.

Egemen, M., and Mohamed, A. N. (2007). A framework for contractors to reach strategically correct bid/no bid and mark-up size decisions. *Building and Environment*, 42(3), 1373-1385.

Hassanein, A. A. and Hakam Z.H. 1996. A bidding decision index for construction contractors. *Building research and information* 24 (4):237-244.

Hegazy, T., and Moselhi, O. (1994). Analogy-based solution to markup estimation problem. *Journal of Computing in Civil Engineering*, 8(1), 72-87.

Hosny, O., and Elhakeem, A. (2012). Simulating the winning bid: A generalized approach for optimum markup estimation. *Automation in Construction*, 22, 357-367.

Leśniak, A., and Plebankiewicz, E. (2013). Modeling the decision-making process concerning participation in construction bidding. *Journal of Management in Engineering*, 31(2), 04014032.

Marzouk, M., and Mohamed, E. (2018). Modeling bid/no bid decisions using fuzzy fault tree. *Construction Innovation*, 18(1), 90-108.

Parvar, J., Lowe, D., Emsley, M., and Duff, R. (2000). Neural networks as a decision support system for the decision to bid process. *Proceeding, ARCOM Conference*. Vol. 1, pp. 209-217

Polat, G., Bingol, B. N., and Uysalol, E. (2014). Modeling bid/no bid decision using adaptive neuro fuzzy inference system (ANFIS): A case study. *Paper presented at the Construction Research Congress 2014*: *Construction in a Global Network*.

Ravanshadnia, M., Rajaie, H., and Abbasian, H. (2011). A comprehensive bid/no-bid decision making framework for construction companies. *Iranian Journal of Science and Technology*. Transactions of Civil Engineering, 35(C1), 95

Wanous, M., Boussabaine, H. A., and Lewis, J. (2003). A neural network bid/no bid model: the case for contractors in Syria. *Construction management and economics*, 21(7), 737-744.