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Multi-criteria Fuzzy Bid/No Bid Pre-Tender Model

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ملخص البحث :-

تقديم أو عدم تقديم عطاءات لمشروعات البناء هي عمليات المقاولين الأساسية. شهرة و سمعة المقاول تأتى من خلال آلاف المشاريع التي ينفذها المقاولون كل عام. والهدف هو أن يكون كل مشروع مربحًا أثناء تنفيذه بما يتماشى مع طموح المقاولين في أن يكونوا روادًا في مجال الاستدامة. تعتمد ربحية المقاولين على نجاح مشاريعهم التي لا يمكن تحقيقها إلا من خلال إدارة مخاطر جيدة. إستراتيجية العطاءات معقدة للغاية و غير مؤكدة و تعتمد على العديد من العوامل الداخلية والخارجية.
تم تطوير وصقل مجموعة من الإجراءات والأدوات لتقييم وإدارة المخاطر والفرص خلال دورة حياة المشروع. يقدم هذا البحث إطارًا شاملاً لإدارة عروض التسعير لدعم قرار تقديم أو عدم تقديم عطاء للمشروع. يتضمن نموذجان قبل المناقصة 1) نموذج خريطة الحرارة لاستبعاد المشروعات ذات الفرصة / المخاطر غير الجذابة قدر الإمكان وفي أقرب وقت ممكن خلال مرحلة الاختيار و 2) نموذج مخاطر المشروع باستخدام نظام المنطق المضبب تقرر ما إذا كنت تريد قرار تقديم أو عدم تقديم عطاء للمشروع. النماذج التي تم تطويرها هي عامة لاستخدامها من قبل المقاولين الكبار والصغار خلال دورة حياة المشروع.

Abstract

To bid or not bid for construction projects is the core contractors' operations. Value is generated through the thousands of projects contractors' execute each year. The goal is for every project to be 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 a good risk management. The bidding strategy is highly complex and uncertain decision making process affected several multitudes and reflection of numerous internal and external factors.
This research introduces a comprehensive bidding management framework to support the decision of bid/no bid. The pre-tender model includes 1) 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 2) a project risk model using fuzzy logic system to decide whether to bid or not to bid. The models developed are generic to be used by large and small contractors during the lifecycle of the project.

Keywords: bid/no bid, markup, risk, opportunity/risk management.

1- INTRODUCTION

One of the most critical decisions that have to be made by contractors in the construction industry is whether or not to bid for a new project when a request of proposal (RFP) is received. The development of a comprehensive proposal for a large project should itself be treated as a project for a project-oriented business. New business is the lifeblood of contractors. Thus, it is important to develop a winning proposal in project management. Decision making at the earliest stages of construction projects involves a process of gathering information from disparate noisy sources. The development and preparation of a proposal takes time and can be costly. Not bidding for a project could result in losing a good opportunity to make substantial profit, improve the contractor’s strength in the industry, gain relationship with the client, and more. However, bidding for inappropriate projects may result in large losses or the consumption of time and resources that could be invested in more profitable projects, ultimately even financial failure of the contractors’ and damage the contractors’ reputation.

Smart contractors realize the importance of considering internal and external factors that affect the bid /no-bid decision before committing themselves to a project. The decision making at this stage is accomplished by two related decisions: first, bid /no-bid decisions that consider factors would help to determine the benefit expected from a particular project and an appropriate bidding strategy; secondly, mark-up decision, which is one of the consequences of the bidding strategy. The development of successful bidding strategies is a key factor to the survival of contractors. The basis of a successful strategy is to filter out losing bid opportunities and concentrate proposal efforts on bid opportunities that, when successful, assist in satisfying the objectives of contractors and prevent contractors from dissipating its energies in preparing a losing proposal.

2- LITERATURE REVIEW

Research in the area of competitive bidding strategy models has been in progress since the mid 1950s. Numerous models have been developed, some of which are designed specifically for construction industry (Stark and Rothkopf, 1979). The usual practice is to make bid decisions on the basis of intuition, derived from a mixture of gut feeling, experience and guesses (Irtishad, 1990). These studies focused to identify the important internal and external factors affecting the contractors’ bid/no bid decision conducted by Ahmad and Minkarah 1988, Shash 1993, Chua and Li 2000, Wanous et al. 2000, Lowe and Parvar 2004, Egemen and Mohamed 2007, Bageis and Fortune 2009 and Ravanshadnia et al. 2011.

The remainder studies introduced the techniques used for bidding support system. These techniques include expected monetary value based on the probability theory (Friedman 1956; Gates 1967; Carr 1982), multi-criteria decision analysis (Seydel and Olson 1990; Cagno et al. 2001), expert systems (Ahmad and Minkarah 1988; Tavakoli and Utomo 1989), neural networks (Li 1996; Moselhi et al. 1993; Hegazy and Moselhi 1994; Dias and Weerasinghe 1996; Li and Love 1999; Li et al. 1999; Lowe and Parvar 2004; Wanous et al. 2003), fuzzy set theory (Eldukair 1990; Fayek 1998; Lai et al. 2002; Lin and Chen 2004) and neurofuzzy (Christodoulou 1998**;** Wanous et al. 2003)

Ballesteros-Pérez (2010) used the iso-score curve graph (iSCG) as a practical tool which enables bidders to place their bids using simple statistical procedures based on previous bidding experiences sharing the same Economic Scoring Formula (ESF).

Dikmen et al. (2007) presented a case-based reasoning model to estimate the risk, opportunity, and competition ratings. These ratings have been further converted to risk and profit markup values by using linear utility functions constructed according to the boundary values that were identified by the respondents considering worst, average, and best scenarios. Egemen and Mohamed (2008) developed knowledge-based system software called SCBMD, which deals systematically with different bidding situations.

Chou (2013) used Fuzzy Analytical Hierarchy Process (FAHP) and regression-based simulation. FAHP method integrates the AHP with fuzzy set theory to determine the weights of factors that influence the cost of a project. The second step, the integration of the cumulative distribution functions that are generated by the Monte Carlo simulation with a regression model yields bid amounts that correspond to various confidence levels.

3- BID/NO BID - PRE-TENDER MODEL

The pre-tender proposes a two stage bidding assessment for the contractors as shown in Figure 1 is divided into two competency assessment scored heat map and project risk model using fuzzy logic system. The proposed approach helps in evaluating the decision and removes any emotion that may be associated with the opportunity. This model acts as a roadmap for a suite of risk and opportunity management procedures, guidelines and templates. The Pre-tender Model controls the level of authorization required to proceed with bid decision. This model guides project teams through a structured presentation of risks and opportunities, facilitating scrutiny and approval at the required level.

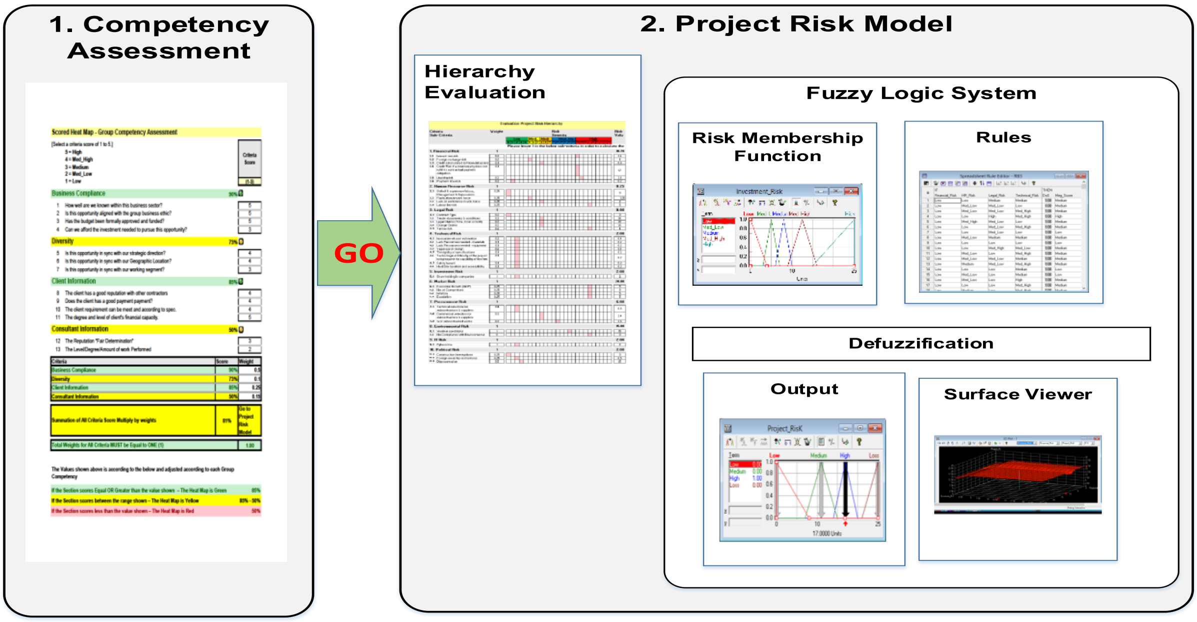

Figure (1): Main function of the pre-tender model

3.1 Group Competency Assessment - Scored Heat Map

The fundamental analysis for new project opportunity is based on a Scored Heat Map which consists from a matrix of the group's core competence. This matrix can be altered according to every year objectives and plans by raising or lowering the threshold score for bidding. This model is used in order to select the "right" projects for the tender-related work. Conceivable new projects are examined on the basis of various parameters such as available project resources, client, geography, consultant, and contract which are crucial to the success of a project, in the company's experience. The Scored Heat Map is used before time and energy are devoted to a tender. Figure 2 shows a template of group competency assessment scored heat map.

Group Competency Assessment - Scored Heat Map

[Select a criteria score of 1 to 5.]

5 = High
4 = Med_High
3 = Medium
2 = Med_Low
1 = Low

		Criteria Score (1-5)
Business Compliance	**0%**	
1	How well are we known within this business sector?	
2	Is this opportunity aligned with the group business ethic?	
3	Has the budget been formally approved and funded?	
4	Can we afford the investment needed to pursue this opportunity?	
Diversity	**0%**	
5	Is this opportunity in sync with our strategic direction?	
6	Is this opportunity in sync with our Geographic Location?	
7	Is this opportunity in sync with our working segment?	
Client Information	**0%**	
8	The client has a good reputation with other contractors	
9	Does the client has a good payment habit?	
10	The client requirement can be meet and according to spec.	
11	The degree and level of client's financial capacity.	
Consultant Information	**0%**	
12	The Reputation "Fair Determination"	
13	The Level/Degree/Amount of work Performed	

Criteria	Score	Weight
Business Compliance	0%	
Diversity	0%	
Client Information	0%	
Consultant Information	0%	

Summation of All Criteria Score Multiply by weights	**0%**	

Total Weights for All Criteria MUST be Equal to ONE (1)	**0.00**

Please enter Weights to Criteria

The Values shown above is according to the below and adjusted according to each Group Strategy

If the Section scores Equal OR Greater than the value shown – The Heat Map is Green	**A%**
If the Section scores between the range shown – The Heat Map is Yellow	**A% - B%**
If the Section scores less than the value shown – The Heat Map is Red	**B%**

Figure (2): Group competency assessment – Scored heat map

The scored heat map is an integration of bid/no bid check list and heat map consisting of 1) Assigning a upper (A%) and lower range (B%) for group competency; 2) answering the questions; 3) Assigning weights to criteria. The approach considered in this model is depending on the final total criteria score where 1) The score is less than lower range then the decision is "No Bid"; 2) The score is between lower range and upper range then the decision is "Go to Project Risk Model"; 3) The score is greater than upper range then the decision is "Go to Project Risk Model".

3.2 Project Risk Model

To help ensure that companies works towards improving risk assessment and create a uniform approach to risk and opportunity, a fuzzy logic model was developed using future-oriented technology from Inform Software Corporation. Figure 3 shows Project Risk model structure using FuzzyTech 5.54d software. The elements of project risk management are divided into ten hierarchical risk categories which are: (1) Financial; (2) Human Resource; (3) Legal; (4) Technical; (5) Investment; (6) Market; (7) Procurement; (8) Environmental; (9) IT; and (10) Political.

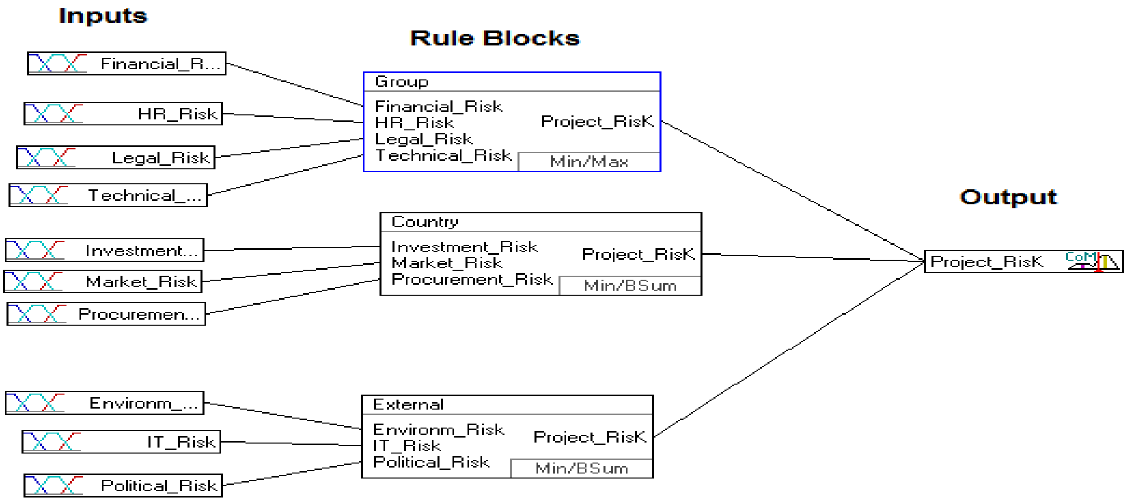

Figure (3): Project risk model structure

The sub-criteria are grouped under the ten risk categories. To allow consistency among the risks, a Risk Severity (RS) of 25 points is used in this study. The (RS) ranges from 0 to 25 where (RS) of 0 implies for low risk, while a (RS) of 25 implies high risk. The (RS) range is divided into five linguistic expressions. The total (RS) depends on the degrees of attainment of these sub-criteria as shown in Figure 4.

Project Risk Hierarchy Evaluation

Risk Severity (RS)

Please Insert 1 in the below sub-criteria in order to calculate the main criteria

Criteria/ Sub-Criteria	Weight	Low					Med_Low			Medium			Med_High						High									Total RS
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1. Financial Risk	0																											0.00
1.1 Interest rate risk																												
1.2 Foreign exchange risk																												
1.3 Credit risks related to Financial assets																												
1.4 Credit Risk if a counterparty does not fulfill its contractual payment obligation																												
1.5 Liquidity risk																												
1.6 Payment flow risk																												
2. Human Resource Risk	0																											0.00
2.1 Skilled & experience labour, Management & Supervision shortages																												
2.2 Fluctuation in work force																												
2.3 Lack of confidence in work force																												
2.4 Labour law risk																												
3. Legal Risk	0																											0.00
3.1 Contract Type																												
3.2 Joint Ventures																												
3.3 Tender documents & conditions																												
3.4 Legal Claims (Time, Cost or both)																												
3.5 Change Orders																												
3.6 Tax law risk																												
4. Technical Risk	0																											0.00
4.1 Inaccurate of cost estimation																												
4.2 Lack Resources needed - materials																												
4.3 Lack Resources needed - equipment																												
4.4 Vagueness of design																												
4.5 The rigidity of specifications																												
4.6 Technological difficulty of the project being beyond the capability of the firm																												
4.7 Safety hazard																												
4.8 Hard Site location and accessibility																												
5. Investment Risk	0																											0.00
5.1 Share holding in companies																												
6. Market Risk	0																											0.00
6.1 Economic Growth (GDP)																												
6.2 No. of Competitors																												
6.3 Inflation																												
6.4 Escalation																												
7. Procurement Risk	0																											0.00
7.1 Technical selection for subcontractors & suppliers																												
7.2 Commercial selection for subcontractors & suppliers																												
7.3 % of subcontracted works																												
8. Environmental Risk	0																											0.00
8.1 Weather conditions																												
8.2 No Compliance with Environmental law																												
9. IT Risk	0																											0.00
9.1 Cybercrime																												
10. Political Risk	0																											0.00
10.1 Construction Interruptions																												
10.2 Foreign ownership restrictions																												
10.3 Dispossession																												

Figure (4): Project risk hierarchy evaluation

Fuzzy logic is used for project risk assessment. To design and implement the proposed system, a list of projects is used to demonstrate the capabilities of the model. Developing the fuzzy logic system involves the following steps:

Step 1 Definition of inputs and output variables. Ten risk severity inputs and one output are used in the fuzzy logic model. The output for the model is called Project Risk. The Watch Window in Figure 5 always displays the input/output values of all system variables. In the Interactive debug mode, the field value is used for manual input.

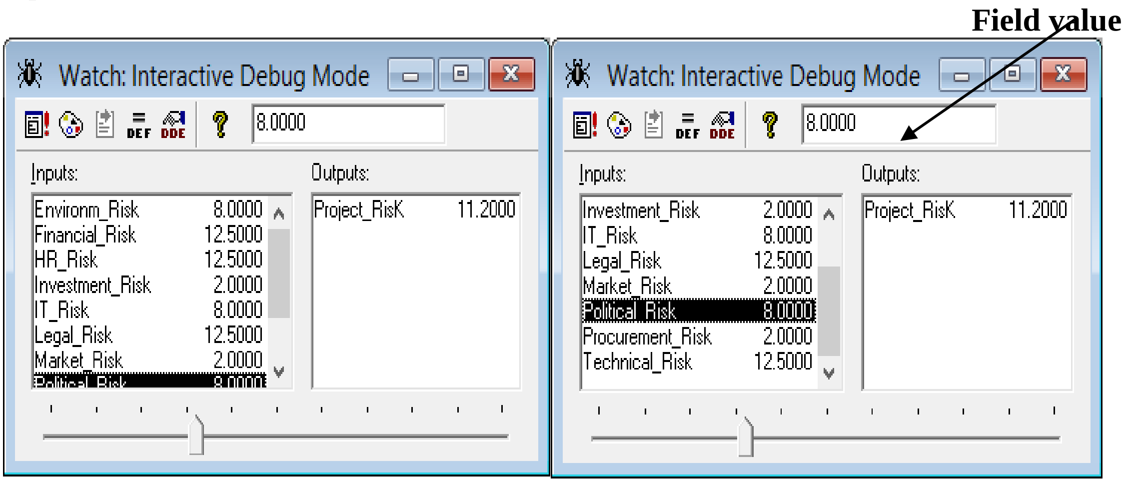

Figure 5 Watch: Interactive Debug Model

Step 2 Defining membership functions (MF) associated to the inputs and output. The degree of membership to which a crisp value belongs to a linguistic value (term) of the linguistic variable, is computed by means of membership functions. This membership degree is represented by a value in the range of 1.0 and 0.0. A membership degree of 0.0 means no membership at all, a degree of 1.0 – absolute membership. The main decisions in this step are:

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

b- Types of membership functions (MF) used for inputs and output is L shaped (triangle type). The range for all input and output variables are from 0 to 25. The upper and lower range for each variable is determined. Figure 6 shows "Financial Risk" as an input variable and "Project Risk" as an output variable.

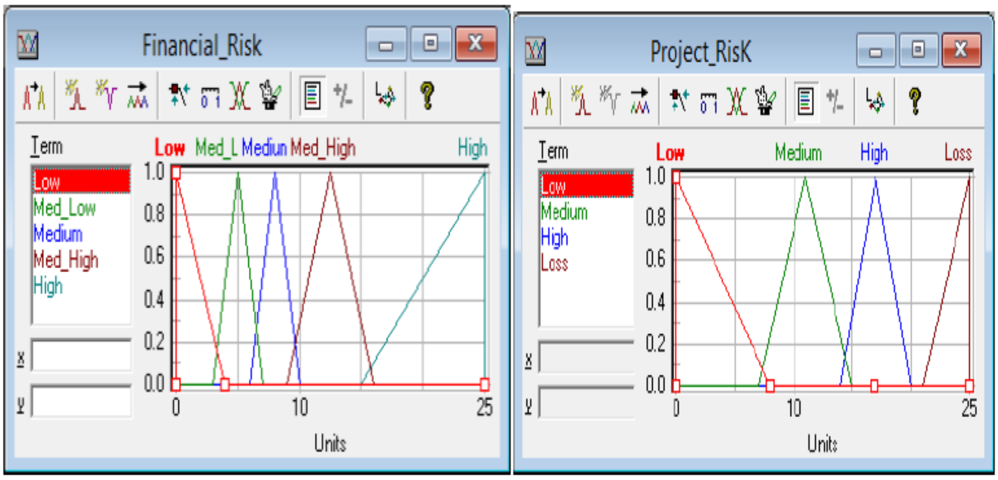

Figure 6 Membership functions for input and output variables

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 brainstorming to extract knowledge and experience and artificial neural network. In fuzzyTECH individual rules are confined into rule blocks to build the system structure. A rule block holds the inference with the production rules and connects system outputs to system inputs. The number of rule blocks that can be defined in a project depends on twelve variables per rule block and 1024 per block. Table 1 shows different rule block categorization, number of linguistic terms for input and output variables, number of rules per block, number of input variable per block and rule generation method used for each rule block. In this model, three rule blocks are used and categorized as below:

a- **Group rule block** including financial, human resource, legal and technical risks.
b- **External rule block** including environmental, IT and political risks
c- **Country rule block** including investment, market and procurement risks

Table 1 Rules blocks and method of generating rules

Rule Block	Block Name	No. of Variables		Risks										Output	Total # of Rules	Rule Constraint	Generate Rules		
		Input	Output	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	y_1			Historical	Expert	ANN
1	**Total**	10	1	5	5	5	5	5	5	5	5	5	5	4	39,062,500	1024	Not Applicable		
2	**Group**	4	1	5	5	5	5							4	2,500	1024	✓	✓	✓
3	**External**	3	1					5	5	5				4	500	1024	✓	✓	
4	**Country**	3	1								5	5	5	4	500	1024	✓	✓	

As shown in above Table 1 group rule block is using the three techniques for generating rules which are:

1- **Historical fuzzy rules** by using old projects executed by the group. Old projects are the main and important source for extracting rules where the inputs and output variables are known.
2- **Expert fuzzy rules** are generated by a committee from risk business manager, project director, estimation/tender manager, commercial manager and construction manager in a brainstorming session to translate the experience and knowledge to

fuzzy rules.

3- **Artificial neural network (ANN)** fuzzy rules are only used to generate remaining rules in group rule block.

Step 4 Defuzzification. At the end of the fuzzy inference, the result for 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 7 illustrates this step.

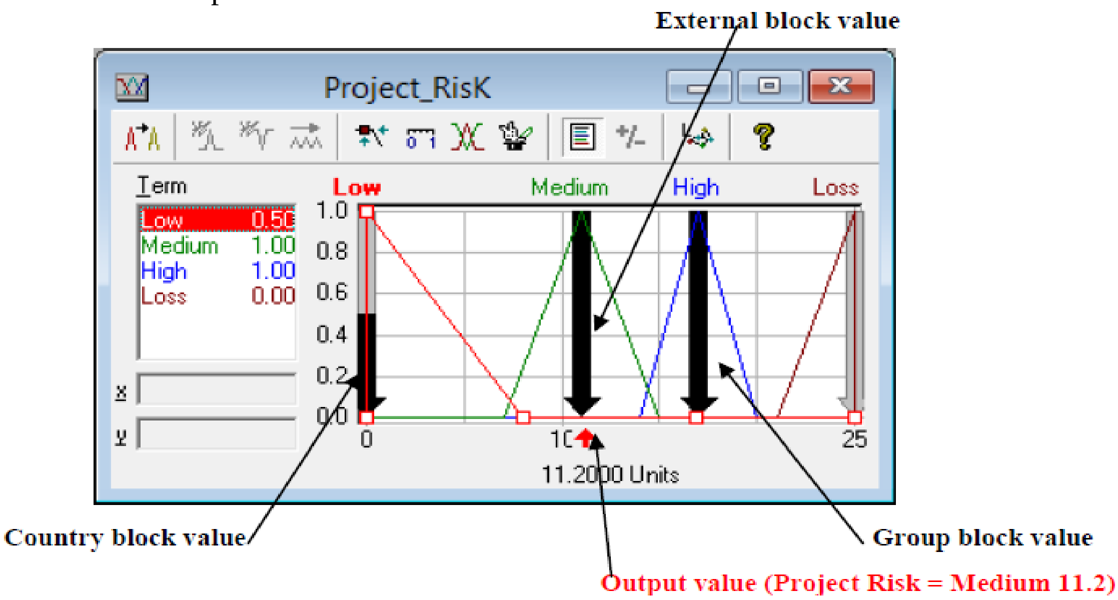

Figure 7 Defuzzification with center of maximum

Because more than one output term can be evaluated as valid, the defuzzification method must compromise between the different results. The Center-of-Maximum Method (CoM) does this by computing a crisp output as a weighted average of the term membership maxima, weighted by the inference results. A "weight" proportional to the degree to which the action is true is placed at the horizontal position of the typical values. The weights are shown as the heights of the black arrows over the gray arrows.

FuzzyTECH's analyzers can be used in any debug mode such as 3D Plot in Figure 8 analyzes the static input/output characteristic of a fuzzy logic system as scalable, rotational three dimensional plot which represents a two input one output case. Accordingly, the 3D plot is equipped with drop-down menus Environmental Risk (input), Financial Risk (input) and Project Risk (output)

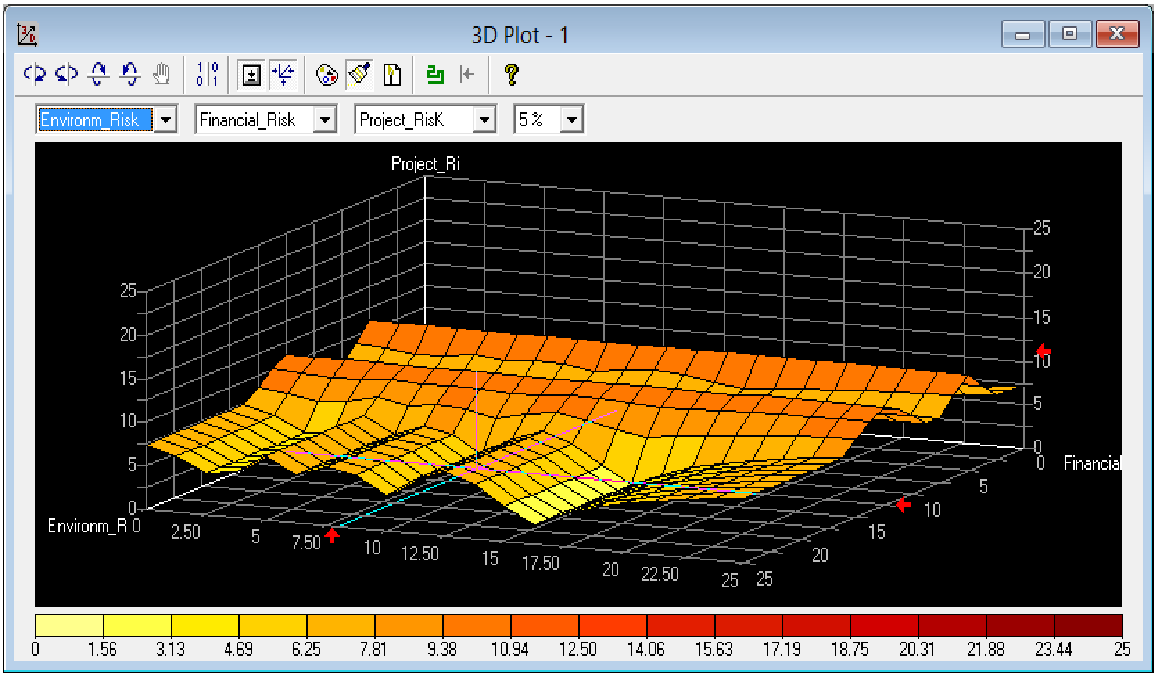

Figure 8 3D Plot for "Environmental Risk", Financial Risk and "Project Risk"

Project Risk Model is a fuzzy logic system which is used as a decision support system (D.S.S) for bidding in the construction. There are four linguistic terms for the "project risk" which are:

1- "Low" then the decision is **"BID"**.
2- "Medium" then the decision to go to **"Strategic Risk System Dynamic Model"**.
3- "High" then the decision is **"No Bid"**.
4- "Loss" where entering the project result in a negative impact in profit and liquidity.

4- CONCLUSION AND RECOMMENDATIONS

The development of decision support system for bid/no bid model using two consecutive approaches to reach the final decision: 1) group competency assessment – scored heat map; 2) project risk model using fuzzy logic system. The user of the model has the utility to store his domain experience and can be adapted to the user environment and utilized for decision making in new bid situations. The bid process is analyzed and the risks governing the decision are identified where a risk hierarchy is developed to elicit risk knowledge pertaining to the tender preparation practices for the contractors. The hierarchy is used to build a database that interacts with the user during the assessment process in a speedy manner. The project risk severity is calculated from the risk hierarchy evaluation to know the decision of each project individually.

The potential improvement to the developed risk and opportunity management system is to develop dashboard for effective risk monitoring where data is aggregated at the area and Group level, and relevant risk indicators are tracked to establish trends and provide business intelligence. This is also where early flags can be provided in case an alarm threshold is reached.

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