Integrated Model for Selection the Prequalification Criteria of Contractor

Waled Alzober and Abdul Razak Yaakub

Abstract—Selection of a contractor is a key decision made by clients and the process of selection a contractor has become an important issue in construction projects. The opportunistic behavior of contractors in low-bids models has been detected from many researchers in various countries and many studies of low bids have found that for the best economic results and good quality, the lowest bid is not considered sufficient to ensure the desired results. A contractor selection problem is a multi-criteria problem. This paper aims to propose integrated model for determining criteria prequalification to select a contractor. The proposed integrated model contains three components. First, Non-parametric tests will use to deal with categorical variables for ranking alternatives. Second, ANN model will apply to determine the relationship between decision factors by using backpropagation multi-layer perceptron (MLP). Third, AHP model will assign the relative importance weightings of several evaluation factors by using Web-HIPRE software to rank the criteria. We hope that the result from proposed model will be encouraging.

Index Terms—Multi-criteria decision-making, AHP, selection criteria, web-HIPRE software, backpropagation multi-layer perceptron, prequalification contractor, non-parametric tests.

I. INTRODUCTION

Effective decision-making is so important especially when considering its irreversible nature, because decision-making possesses far-reaching consequences for the organization [1], [2]. A complex or unstructured problem is based on multi criteria not on a single criterion; therefore, the model has to deal with multi criteria simultaneously, and GDMs are required [3].

A correct decision-making is required for selecting the appropriate contractor for a construction project. Selection of a contractor is a key decision made by clients and the process of selection a contractor has become an important issue in construction projects [4]. Successful implementation of a construction project is influenced significantly by taking the appropriate decision at the appropriate time [5]. Often, the competitive bidding model in public projects based on the price for evaluating the bid is used around the world [6]. The low-bid method is also commonly used in the construction industry in many countries; generally it referred to as the competitive bidding method and is based the lowest bid being the winner [6], [7]. This method has been used since the nineteenth century. For example, in the United States New

York State has been using the lowest bid method for 150 years [8].

The opportunistic behavior of contractors in low-bids models has been detected from many researchers in various countries such as France and Portugal [9], the United States [10], and Taiwan [11], [12]. In this instance, the bid prize, which is initially given and considered to be the lowest cost for the execution of the program, does not end up being the actual cost to finish the project [6]. Many studies of low bids have found that for the best economic results and good quality, the lowest bid is not considered sufficient to ensure the desired results [13]. Finding a new route has become important to create the best model for contractor selection [6].

This paper aims to propose integrated model between AHP and ANN models for determining criteria prequalification to select a contractor.

II. PREQUALIFICATION PROCESS FOR SELECTION A CONTRACTOR

A contractor selection problem is a multi-criteria problem [3], [14]-[17]. Many multi-criteria techniques have been proposed and applied to such problems solution [3], [4], [16]-[20]. Generally, the process of contractor selection contains two stages, namely, prequalification and bid evaluation [4]. The first stage includes an invitation to a number of potential contractors to bid and who have been verified on the basis on the predefined criteria needed to get a short list, the second stage is the evaluation process to select the suitable contractor from the short list who is the winner of the bidding. The key objective of the governmental tendering or non-governmental tendering of a selection process of a contractor for allowing the exclusion of a contractor who suffers from a lack of efficiency, lack of funding, or does not have the necessary experience for a contract which reduces the problems that might occur in the work and also raises the quality and decreases effort and money.

III. CRITERIA PREQUALIFICATION OF CONSTRUCTION CONTRACTOR

Often, the bid price has been the most important criterion (or sometimes the sole criterion) in the selection of the contractor. However, the contractor's capability to fulfill the terms and conditions of the bid satisfactorily is an element more important now in awarding the tender [21].

Ng and Skitmore [22] highlighted the prequalification criteria of previous studies in the literature review. Previous studies showed that contractor selection should not be based

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solely on obligations specified in the tender such as tender price but also on other criteria.

TABLE I: MAIN CRITERIA AND SUB-CRITERIA FOR CONTRACTOR PREQUALIFICATION

Criteria	Sub-criteria
Financial stability	Financial soundness
	Credit rating / Credit history
	Yearly turnover
	Leverage
	Liquidity
	Profitability
Management ability	Management knowledge
	Management capability
	Quality management system
	Project management system
	Risk management
Technical capacity	Qualification of staff
	Experience of staff
	Knowledge of particular construction method
	Contractor's IT knowledge
	Qualification of contractor
Experience	Type of past project completed
	Size of past project completed
	Number of projects completed
	Experience in local area
	Overall experience
	Proposed project time schedule
Past performance	Quality level of projects performance (e.g., ISO: 1400)
	Projects completed on time
	Projects completed on budget
	Past record of conflict and disputes
	Present workload and capability to support the current project
	Lack of communication
Reputation	Relationship with sub-contractors
	Cooperation with contactors
	Client satisfaction
	Relationship with supplier
	Past failures in completed projects
	Number of years in construction
	Claims and litigation
Resources	Labor and equipment
	Number of staff
	Adequacy of plant resources
	Number of direct workers available for the project
Occupational health and safety	Management safety accountability
	Health and safety management system
	Health and safety records
	Safety performance
	Insurance policy
	Occupational safety and health administration rate (OSHAIR)
Quality	Quality control
	Quality assurance
	Tender quality
	Safety initiatives record
	Query response timeliness
Environmental	Waste disposal during construction
	Environmental plan during construction
	Materials and substances used in the project
Organization capability	Age in business
	Size of the company
	Company image
	Skilled manpower
	Organizational structure
Planning and control	Plant maintenance programs
	Flexibility in the critical paths
	Failure to comply with quality specifications
	Tender price and estimates
	Control plan

The literature review by Hatush and Skitmore [23], and Topcu [24] shown that the most widely accepted criteria for prequalification of the contractor were: financial stability, management and technical ability, contractor's experience, contractor's performance, resources, quality management, plant and human resources, health and safety and environmental concerns.

Finding criteria based on the sub-criteria properly or establishing a model that includes prequalification processes by all their conditions has been difficult. There are many studies in many countries in this regard which have looked at main criteria and sub-criteria for contractor evaluation [3], [15]-[17], [25]-[36]. These studies have taken into account some criteria considered important for achieving more than one objective. An example of that is for a bank arrangement is important for both time and cost but less important for quality. Another example is management knowledge and project management organization are considered important for time and quality but less important for cost. On the other hand, some criteria are considered important for just one objective and much less to others., An example is that that technical personnel are just important for quality [17]. El-Sawalhi *et al.* [3], El-Sawalhi *et al.* [27] identified seven criteria present in the available literature and also added criterion that were important for qualification process in their e-mail questionnaire. There are seven factors extracted, which reflected the importance of contractors' performance across time, cost and quality success objectives by using multiple regression analysis [37]. Doloi *et al.* [26] used structural equation modeling for studying 29 contractors' qualification criteria, which had been identified in published literature [37]-[41] related with contractors' performance in medium size construction projects in Australia. Both the expertise and performance of contractor had a significant role in successful delivery of a project [37]. The study found that technical planning and controlling expertise of contractor have major impact for achieving success in projects. The conclusion of the both studies of Doloi *et al.* [26], Doloi [37], which focused on contractor success criteria to project success objectives, was that it remains unclear whether contractor success criteria were reported from an immediate post-construction evaluation or from long-term historical perception. According to Plebankiewicz [33] five main criteria and twenty-one sub-criteria could be distinguished from previous literature review. Financial standing, technical ability, management capability, health and safety, and reputation were the main criteria based on studies such as [17], [23], [42]-[45].

For saving costs and time, the online survey research is easier and faster because of survey authoring, software packages and online survey services [46]. Alzahrani and Emsley [25] used Survey Monkey web-based survey software to save on costs and time in contacting many respondents in a short amount of time. A questionnaire is one way to collect important data needed though the contractors' answers in the style of the questionnaire probably will be skewed as much as possible to their advantage [15]. Therefore, though the questionnaire has some advantages, it also has major disadvantages so an approach must be developed to create a more an objective method in which a

database allows comparisons among the contractors equally, that is easy to use, that gives the owner an efficient mechanism for the analysis of the data which the contractor has submitted.

The criteria and sub-criteria for selection contractor will be adopted in this study based on the literature review surveys collected from previously published research and the rank of all adopted sub-criteria considered from the literature review as well. The literature review included the following: [3], [15]-[17], [22], [25]-[27], [30], [31], [33], [35], [37], [38], [47]-[52]. Adopted criteria and sub-criteria for selection contractor are shown in Table I.

IV. MODELS FOR SELECTION CRITERIA PREQUALIFICATION OF A CONTRACTOR

A lot of studies as mentioned above used many techniques for determining criteria prequalification for selection a contractor. The majority of last studies which deal with problem of a contractor selection as multi-criteria problem uses methods of decision analysis in their models or approaches, but their approaches consider time, quality and price as single main decision criteria to evaluate and choose a contractor. El-Sawalhi *et al.* [3] studied and compared between the published contractor pre-qualification models abilities. Comparison of these models is shown in Table II.

Table II clearly shows that each technique has own strengths and weaknesses; thus, there is an urgent need to integrate some models to cover these disadvantages. AHP is comprehensive method and the most used widely MCDM method or tool due to its simplicity, ease of use, and great

flexibility; [53]-[56]. Therefore, this method can be adopted in this study. According to Subramanian and Ramanathan [55], there is need to extend the use of AHP to areas regarding project management issues such as aircraft building, construction industries, manufacturing industries, etc; for most cases in project management, AHP has been used as a standalone methodology. Another finding from this comparison is that some issues (weaknesses) related to the AHP model, such as deal with subjective judgment, non-linear behaviour, uncertainty and risks considered, and adaptive model can be covered by using ANN model. In MCDM approaches, only a very limited number of decision alternatives can be compared by AHP method [57]. According to study of Ho [53], Subramanian and Ramanathan [55] reviewed published integrated AHP articles, there are decision tools such as data envelopment analysis; Strengths, Weaknesses, Threats and Opportunities (SWOT) analysis; meta-heuristics; and quality function deployment were commonly combined with AHP. Other tools as Mathematical programming considered too commonly combined with AHP [53]. Combined AHP with some meta-heuristics approaches such as ANN, GA, SA, and TS are suitable for solving the combinatorial optimization problems with multiple criteria, where the meta-heuristics have proved more efficient than the exact algorithms to solve hard optimization problems [53]. A combinatorial optimization problem is an optimization problem with discrete variables. Subsequently, combined AHP with some meta-heuristics approaches will be suitable to solve the problem of selecting criteria prequalification of contractor.

TABLE II: COMPARISONS BETWEEN PUBLISHED MCDM MODELS ABILITIES

	Multi-Attribute Analysis (MAA)	Fuzzy Set	Analytical Hierarchy Process (AHP)	Multi-Attribute Utility	Case-Based Reasoning (CBR)	Artificial Neural Networks (ANN)
Group decision	–	–	X	–	X	X
Deal with subjective judgment	–	X	–	X	X	X
Non-linear behavior	–	X	–	–	X	X
Uncertainty and risks considered	–	X	–	X	X	X
No needs training of the system	X	X	X	X	–	–
Ability to interpret the results	X	X	X	X	–	–
Understanding the mathematical behavior	X	X	X	X	–	–
Adaptive model	–	–	–	–	X	X
Multiple criteria simultaneously	–	X	X	X	X	X
Not acquire high knowledge to implement	X	–	X	–	–	X
Qualitative and quantitative data	–	X	X	X	X	X

V. PROPOSED MODEL

The proposed framework of this study as shown in figure 1 has three main stages as follow:

1) Usage non-parametric tests to rank alternatives.

2) Usage multilayer perceptron (MLP) algorithm to obtain the weights of criteria.

3) AHP model to get the final rank of criteria and check sensitivity analysis of output.

The adopted integrated model contains two models as

following:

A. Non-Parametric Tests

The first stage of proposed framework starts with defines project requirements and identification of criteria and alternatives. Non-parametric tests will be used to deal with categorical variables to rank alternatives using Statistical Package for the Social Sciences (SPSS) 19.0.

Fig. 1. Framework of proposed integrated model.

B. Multilayer Perceptron (MLP) Algorithm

After ranking the alternatives the multilayer perceptron (MLP) algorithm will be used to obtain the weights of criteria using Statistical Package for the Social Sciences (SPSS) 19.0.

C. AHP Model

Usage AHP model is last stage in the proposed framework. The weights that obtained by MLP will be used by decision maker to fill the AHP decision matrix to obtain the final weights of criteria for ranking the criteria, apply sensitivity analysis to check the output.

This stage will be done by using Web-HIPRE software. There are tools of Web-based decision support for decision making [58]. Web-HIPRE software is one of these tools. Web-HIPRE released in 1998 which is a web version of the earlier HIPRE 3+ software developed by Hamalainen and Lauri in the mid-1990s, located on <http://www.hipre.hut.fi> [59], [60]. Fig. 2 shows Web-HIPRE on the DSS-map.

Fig. 2. Web-HIPRE on the DSS-map.

VI. SCOPE AND LIMITATION OF STUDY

This study focuses to develop a framework for DSS by propose integrated model between AHP, ANN and Non-parametric tests to handle semi and unstructured problem.

The developed framework of DSS will be provided based on information collected. A contractor selection based on the tendering process in public Malaysian construction industry in which a real case study will be obtained from University Utara Malaysia (UUM) to be used to evaluate an applied

prototype to determine the accuracy and effectiveness of the framework's performance by using the quantitative and qualitative approaches.

VII. CONCLUSION

A complex or unstructured problem is based on multi criteria not on a single criterion. A contractor selection problem is a multi-criteria problem. A correct decision-making is required for selecting the appropriate contractor for a construction project. Selection of a contractor is a key decision made by clients and the process of selection a contractor has become an important issue in construction projects. This paper aims to propose integrated model between AHP and ANN models for determining criteria prequalification to select a contractor. Data collection provided through tendering project in public Malaysian construction industry in which a real case study will be obtained from University Utara Malaysia (UUM). We think that the proposed model will provide a good and encouraging result for determining criteria prequalification to select a contractor.

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