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Factors influencing construction contractor selection in Egypt

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ABSTRACT

The Egyptian market often suffers from delayed or unappropriated quality delivery projects. And this is due to many economic, political, and climatic reasons unique to each country, but what concerns us in this research is the role of the accountable contractor for project execution. Therefore, contractor selection is an essential step, along with project design and the feasibility study. And this is what this paper aims to do: study and discover the most essential factors that must be considered and evaluated when selecting a contractor from the viewpoint of the key relevant parties in the Egyptian construction industry. A survey was carried out through literature reviews of international journal-published research to get the most common important factors from different countries worldwide. Therefore, using them to conduct a questionnaire distributed to a sample of specialists in different fields of the Egyptian construction industry to quantify respondents' opinions and to deal with human linguistic and vague descriptions, triangular fuzzy sets have been used to represent each specialist's perception. So, forty-eight factors were aggregated in a questionnaire to be evaluated by decision makers who expressed their rating of contractors' performance in linguistic terms, and these factors were converted using the fuzzy Delphi technique into numerical values used as equation inputs, resulting in accurate and preferably main seven factors, which make the selection process more consistent and realistic. Those factors are recommended to be taken into consideration and evaluated for each candidate contractor.

1. Introduction

The construction industry is characterized by cost and time overruns and problems with quality standards, which lead to claims, counterclaims, and litigation. All these risks can be minimized by selecting an appropriate contractor, which is not easy at all and represents a huge challenge to the construction customer (Singh and Robert, 2005). Most of private construction institutes use different procedures for evaluating tender bids to select the proper contractor for the job. Conversely, the public sector selects the contractor mainly based on the tender price (Barrie and Paulson, 1992) due to being publicly accountable for their money. On the other hand, the evaluation of contractors based on multiple criteria is becoming more popular, which is largely dependent on the variability of construction projects and the subjective judgement of decision-makers (Singh and Robert, 2005). Therefore, contractor prequalification and bid evaluation took place within the overall procurement process, which involved a wide range of decision criteria to be taken into consideration by the employee in charge (Russell et al, 1988). The pre-qualification process is summarized into four main steps: (1) criteria selection; (2) each criteria weight calculation; (3) scoring contractors versus each criterion; and (4) establishing a ranking model and selecting contractors (Lam et al, 2011; Afshar et al, 2017). There are various models for contractor prequalification, but they are ineffective without a well-studied set of selection criteria. Thus, it is necessary to review what is already known about contractor prequalification criteria and increase academic and industrial understanding of the

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evaluation criteria (Jafari, 2013).

In the 182/2018 Egyptian tender law, the contractor's evaluation is dominated by the principle of accepting the lowest bid price from the contractors who have a technical specification that complies with the tender terms and conditions. The technical proposal of the contractor can be evaluated using the "point system", where the contractor's bid price is divided by his technical score, and then the contractors are prioritized according to the calculated ratio (Shehata and Nassar, 2018). The main issue is that there are no specific technical criteria specified for the local construction industry market; the typical criteria might have a significant impact on a particular area's choices while having little impact on the Egyptian market (El Agroudy et al, 2009).

So, the main objective of this research is to identify the factors that parties in the Egyptian construction industry consider to be the most important in influencing contractor selection in order to avoid overstating the importance of one factor relative to another and to serve as a database for prequalifying, evaluating, and selecting contractor models.

2. Literature Review

2.1. contractors' prequalification Factors

In (Hatush and Skitmore, 1997) research, the essential criteria used to rate contractors in the prequalification and bid evaluation stages were divided into five points: financial soundness, technical ability, managerial capability, safety, and reputation of the contractor. Therefore, in the (Doloi,2009) research, a total of 43 technical criteria were derived from an analytical research methodology during an organized questionnaire study of construction projects, and based on this, it has been determined what the qualities' relative importance and effects are as seven factors that were significant to contractors' performance were identified through the factor analysis, including: (1) the viability of the company and its workforce; (2) planning and control; (3) quality management; (4) prior performance; (5) risk management; (6) organizational capability; and (7) commitment and dedication.

Also, in (Plebankiewicz, 2010) paper, the contractor's estimation of qualifying factors for Polish public clients was carried out based on demands stated by clients in restricted tenders announced in 2007. As for private clients, a questionnaire was sent to 27 private clients at the turn of 2006/2007. The findings demonstrate that public clients employ just one criterion to qualify candidates for the second stage of the tendering process, typically the contractor's experience, while private clients place a high priority on a contractor's technical capabilities. As a result, the top features in the rankings are the employees' qualifications, the equipment they have, their experience with similar investments, and their quality, while the contractor's financial stability is valued at a lesser level and project management-related criteria receive the least attention. In another way of thinking, (Rashvand et al, 2015) undertook a study to investigate the flaws of the present prequalification evaluation for contractor selection. Its approach is based on a thorough examination of the literature and an expert survey in which the relevance of data taken from the literature was evaluated by subject-matter experts. Among the prequalification criteria, the current assessment of financial position was regarded as the most important one, followed by technical competence and managerial capability, with 97%, 94%, and 85% critical indexes, respectively. Despite this, contractor reputation and health and safety performance received the lowest rankings. Consequently, in (Acheamfour et al, 2019) research, to maintain credibility, 26 Scopus archived papers that were published only in peer-reviewed journals were subjected to content analysis to investigate the key contractor pre-qualification criteria. The results were classified into 41 criteria and thus into six main categories: technical, management, financial, reputational, and general experience aspects, with limited considerations for health, safety, and environmental aspects.

In a comprehensive new study, the subsequent literature works are used to analyse how pre-qualification criteria affect the three project success factors of time, cost, and quality as follows: (1) financial capacity: hiring contractors with sufficient financial resources enables consistent task execution and prevents time overruns. On the contrary, if the funds are not sufficient, they will be unable to purchase top-notch machinery, highly competent labour, and high-quality materials; (2) technical aspects: the expertise of the contractor determines the completion rate of construction projects. When they have completed similar projects in the past, they will be better able to react to and overcome unpredictable project obstacles as they arise; (3) management aspects: during the prequalification stage, clients must also assess a contractor's capacity to manage the entire project, which includes preparation, management, teamwork, command, and control; (4) environmental, health and safety concerns: accident and injury costs, according to previous statistics, amount to about 8.5% of the contract price as they slow down the construction process; (5) reputation considerations: past achievements and the attitude shown by a contractor in prior projects are important variables; however, rating a contractor's reputation is extremely challenging and largely subjective, so that's why it receives a low ranking for importance (Patil et al, 2020).

In late studies, as an example of simple techniques, the respondents were given a list of twenty-two criteria and asked to give each one a yes or no answer. Therefore, by giving them a grade, the mean value was calculated. So, seven factors with a higher than 1.90 mean value were identified: (1) a good relationship between the contractor and client; (2) meeting the expectations of past performance; (3) ability to manage supplies and equipment; (4) safety record; (5) experience obtained from past projects; (6) completing projects within schedule and without delay; and (7) field experience (Sathish et al, 2021). Also in another technique, a questionnaire was used to gather information about a company's general capability, financial capability, technical and equipment capability, managerial capability, and professional experience, and to determine the importance and influence of contractor evaluation criteria, the CRITIC approach was used (Naik et al, 2021).

As for Egypt, Salama conducted in his article a questionnaire distributed to 100 project managers, with a high response rate

of 72%. They strongly recommend that Egypt's Act 89/1989 must mention the proper relative weights of the technical criteria to be employed in complicated projects. Also, the Egyptian construction industry needs a strong database system that gives the decision-maker precise contractor selection process information. This data should include technical expertise, managerial capability, prior owner-contractor interactions, past performance and quality, failures, and the contractor's history of arbitration and claim filings (Salama et al, 2006). In an extensive study published in 2018, Atia used an investigational technique to conduct a questionnaire to gather real data from essential parties. Results considered "experience, working schedule, bid specifics, general information and registration details, and management and organization of the contractor" as the most important factors out of a total of 15 main criteria and 67 sub-criteria that are essential in evaluating Egyptian contractors (Atia et al, 2018). And in brand new research in Egypt (Naji et al, 2022), it was demonstrated that financial stability was ranked first, followed by offered price, proposed delivery date, experience with similar projects, past history, qualifications of engineers and technical staff, warranty, and after-sales services.

There is an ongoing need to test the market and follow its changes as a result of rapid urbanisation, local and global financial changes, and the repercussions of developers' goals and investment plans. Additionally, a wide range of selection criteria that were overlooked in earlier research of a similar nature carried out in several countries, particularly Egypt, must be recovered and re-examined, as well as the weights of these criteria.

The prequalification and selection factors in the last two papers were approximately the same but with different rankings. One of them prioritises experience and its sub-criteria over financial stability and its sub- criteria. So, there was a need to examine more criteria-weighting methods, trying to get closer to human thinking and its ambiguity by using fuzzy sets and targeting the most important parties in the field as decision-makers.

2.2. Fuzzy Set Theory

Prequalification is a multi-criteria decision matter, highly reliant on the uncertainty and ambiguity nature of construction works as well as the subjective judgement of the decision-maker. As a result, fuzzy set theory is chosen as the basis to deal with this procedure because it has the capability of using linguistic evaluation or precise evaluation of the contractor's performance on qualitative or quantitative criteria, as appropriate (Nieto-Morote and Ruz-Vila, 2012).

Linguistic variables are ones whose data are phrases or words from a speech. So, when the performance of a goal is described as a linguistic variable, its values can be described by phrases like very small, small, medium, large, and very large (Zadeh,1975). To overcome the fact that linguistic terms are not mathematically operable, a fuzzy number is assigned to represent the meaning of each generic verbal term. Mainly, the most commonly applied are trapezoidal and triangular fuzzy numbers (Mayor and Trillas, 1986)

In 1965, Zadeh was the first one that introduced the fuzzy theory to express and compute with uncertain data, whether due to measurement inaccuracy, a shortage of details, or the use of vague linguistic terminology in the decision-making process. Therefore, fuzzy assessment is used as the basis of many contractor selection models as in (Plebankiewicz, 2009) research, which considered both contractor evaluation factors and the goals construction owners needed. As owners express their objectives and selection criteria for the contractors using linguistic variables. So, he resorted to using fuzzy sets theory to prepare a prequalification computer programme supporting model. Also, in the (Nieto-Morote and Ruz-Vila, 2012) research, a triangular fuzzy approach was used to facilitate the process of assessing both the weights of criteria and the level of performance of each contractor with respect to each qualitative criterion, and MATLAB was used to handle the computational process to tackle the problem faster and more precisely. As it is used to tackle the ambiguity in human experience, this makes it the perfect extension of the analytical hierarchy process (AHP) decision-making tool to solve contractor prequalification problems that are full of uncertainties and vagueness (Bishaw, 2019).

So, fuzzy logic is used to achieve the objective of this paper, which is to provide a framework that enables decision-makers to express their evaluation of impacting factors in linguistic terms that more closely correspond to real-life circumstances by using the fuzzy methodology that produces an equivalent numeric crisp output, to give each factor its real importance with respect to the Egyptian market.

An illustration of this technique in use is a fuzzy logic model that was used to prequalify and choose the best contractor for a residential compound in Egypt that included 20 villas and was revealed in a small tendering of four grade three contractors. A fuzzy logic MATLAB inference system was used to rate each contractor based on eleven factors that were established based on statistical analysis, including financial soundness, technical aptitude, management capability, resources, reputation, and general acceptability. There are two basic components to this interface: one is for technical evaluation, and the other is for financial evaluation. When the eleven inputs are entered, the developed system converts them into six key criteria that the fuzzy logic model will use. Then the "Evaluate" button can be used by the user to examine the outputs, which rank the contractors from best to worst. Then the model was validated by a straightforward questionnaire that was given to twelve decision-makers to test the technique and rate various contractors on earlier projects. The median score is 3.19 out of 4.0 (or 79.75%), which is deemed respectable level and demonstrates the applicability of the established model (El Agroudy et al, 2009).

3. Methodology

Since more than 50 years ago, the Delphi technique has been used to gather collective knowledge. It bases its conclusions on the opinions of experts. The quantification of experts' opinions in traditional Delphi approaches cannot accurately capture the way humans think. Therefore, applying fuzzy numbers to

decision-making in the real world improves decision-making by being more consistent with human linguistic and sometimes hazy descriptions. To describe the fuzzy Delphi technique implementation algorithm, it is necessary to distinguish between two alternative applications of the Delphi approach: screening criteria and forecasting. Researchers are attempting to pinpoint the most fundamental components of a phenomenon in this study and similar exploratory and heuristic ones. and other forecasting-related studies are also being carried out.

There are several procedures in fuzzy spectrum development: aggregation of experts' opinions, defuzzification, and reaching a consensus. Various types of Likert scales can easily be used to gather opinions from experts (Habibi et al, 2015).

In the following sections, the detailed process from selecting the contractor selection factors to applying the fuzzy Delphi spectrum is described as it could be abbreviated in those five steps:

1. Reviewing the available literature related to contractor selection factors.
2. Preparing the questionnaire including the most common factors and distribute it to a sample of specialists in different fields of construction.
3. Applying the fuzzy decision-making framework, which involves:
   a) defining and explaining the types of fuzzy numbers that decision-makers should use as well as their membership assignments.
   b) establishing the scale of preferences that decision-makers will use.
4. Collecting and sorting respondents' opinions and giving them their fuzzy values.
5. Defuzzification using triangular fuzzy approach and converts final fuzzy data into a crisp and intelligible number.

The procedure was broken down into a few simple steps, and the following sections provide more details.

3.1. Preparing and distributing the questionnaire

A great majority of researchers have used the questionnaire survey to collect different groups of experts' opinions to determine or rank the pre-qualification criteria (Jafari, 2013). This is also what has been applied in this research. The objective of this questionnaire is to collect the opinions of experts. Therefore, respondents' evaluations of these factors will contribute to supporting the committee's decision-makers in evaluating the technical envelopes in the screening and selection processes.

The questionnaire is prepared, including a total of 48 common influencing factors under the umbrella of nine main categories collected from the previous literature, and distributed to around 200 respondents, including 24 site engineers with different experience periods ranging between 10 and 15 years; 30 project managers with more than 5 years' experience working for both the public and private sectors; 23 contractors with different rankings ranging from the fourth to the second degree; 27 tender and pricing engineers working in both private and public institutes; 17 senior planning engineers working for large private companies; 35 private construction consulting offices with more than 10 years' experience in the Egyptian market; and of course, the greatest focus was on the owners and financiers of construction projects, including 19 governmental agencies and 25 private ones working in the field of building and road construction for more than 10 years.

Candidate respondents were asked to estimate the importance of the following factors influencing the selection of a suitable contractor based on a scale (1 to 5 points), where 1 is extremely unimportant, 2 is unimportant, 3 is neutral, 4 is important, and 5 is extremely important, as represented in Table 1, which summarises the final 48 factors that were assessed upon them.

Table1. Importance of influencing contractor selection factors assessment

Factors influencing contractor selection		Importance of contractor selection factors				
		Extremely unimportant (1)	Unimportant (2)	Neutral (3)	Important (4)	Extremely important (5)
past performance	Compliance with specifications and quality standards					
	Cost and schedule overruns in the past projects					
	attitude towards correcting faulty or incomplete works					
	attitude towards claims and counterclaims					
	relationship with past clients and/or subcontractors and suppliers					
	past failure (failure to have a contract completed)					
past experience	types of projects completed					
	scale of projects completed					
	experience in local area					

	past experience with the client					
	Experience of the contractor in constructing similar structures					
Performance Potential	Size of structure					
	project specific criteria					
	contract conditions					
	Construction program					
	current workload					
	Ownership of construction machinery (plant and equipment)					
Financial Capabilities	Financial stability and risk prevention skills					
	Financial statement (credit rating)					
	banking arrangement and bonding					
	budget and finances management for the project					
	financial guarantees					
	Taxation details					
	Profit during last three years					
	Turnover history					
	reliable financing contractor sources					
	innovative methods of financing					
Management capability	availability of qualified managerial staff					
	ability to timely complete projects with workload					
	certified management systems (quality system, safety policy)					
	manpower qualification					
health and safety	safety plan and safety recording system					
	experience modification rating					
	management safety accountability					
	OSHA incident rate					
	Propose adequate plan to control safety environmental sanitation					
	Propose adequate plan to control safety environmental sanitation					
Technical competences and methodology	ISO quality certification					
	Propose plan to manage quality and stay on schedule and within budget					
	Relation with other partners in the project					
	Propose logical approach to tasks and issues of the project					
	Capacity to understand and meet requires of owner					
Contractor reputation	Quality assurance plan					
	Quality management program					
	Quality and durability of the contractor's work					
	Reputation of the contractor and team member					
Tender characteristics	Time for the preparation of the bid					
	Criteria of bid selection					

3.2. Applying the fuzzy framework

After collecting experts opinions, Triangular fuzzy function is applied as in (Habibi et al, 2015) research in which an equivalent triangular fuzzy number (TFN) consisting of three real numbers (a_1,a_2,a_3) is assigned for each verbal expression.

Where, a_1 is the highest value of the fuzzy number, a_2 is the most likely and a_3 is the lowest, as shown in Fig. 1.

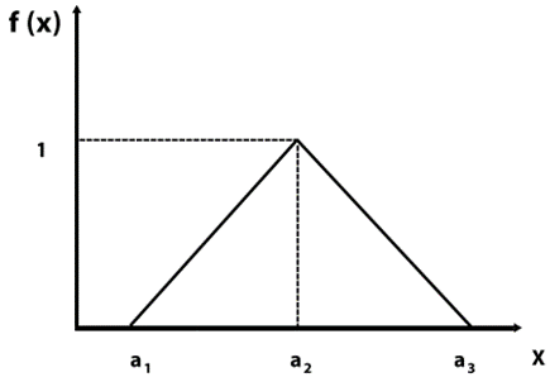

Fig. 1. Triangular fuzzy spectrum

So, for each importance voting verbal expression there is a fuzzy triangular equivalent number, as shown in Table 2.

Table 2 Equivalent. triangular fuzzy number of verbal appraisals

Extremely unimportant	(0,0,0.25)
Unimportant	(0,0.25,0.5)
Neutral	(0.25,0.5,0.75)
Important	(0.5,0.75,1)
Extremely important	(0.75,1,1)

3.3. Aggregating and Defuzzification of fuzzy numbers

After assigning fuzzy equivalence to each decision maker's verbal opinions, they have been aggregated statistically, preparing for the next step, called defuzzification, which is a process designed to turn the final fuzzy data into a crisp number that can be compared to the threshold. A crisp number is determined by the maximum of the three averages x1, x2, and x3 that are calculated by using the following equations:

$$F = (a1, a2, a3)$$

$$x1=((a1+2a2+a3))/3\ldots\ldots\ldots\ldots \quad (1)$$

$$x2=((a1+2a2+a3))/4\ldots\ldots\ldots\ldots \quad (2)$$

$$x3=((al+4a2+a3))/6\ldots\ldots\ldots\ldots \quad (3)$$

As for the threshold value, there are a lot of scientific methods for determining the level of consensus using the Delphi technique. The most popular one due to its simple application is Kendall's method, which measures current agreement with Kendall's coefficient concordance (Kendall's W), which is calculated along with the mean rank and standard deviation. It ranges from 0 to 1, indicating that a strong degree of consensus is reached when W > 0.7 (Habibi et al, 2014).

As a threshold is identified, any factor that fails to meet this value is immediately eliminated from consideration. Thus, the required factors exceeding it remain, which in this study are seven factors.

4. Results

48 factors—the most common—were restored as a summary of investigations from previous publications that deal with the same local problem as Egypt and are looking to discover the most crucial variables used in the selection of contractors. Then a questionnaire gathering those factors was conducted and distributed to 200 different construction field candidates to evaluate those factors. The Delphi questionnaire received 164 replies representing an average response rate of 82%, which is a high percentage. Comprising 12% of site engineers, 15% of project managers, 12% of contractor's companies 13% of tender and pricing engineers, 9% of senior planning engineers, 18% of private consulting companies, and 9% and 12%, respectively, of public and private building and road construction agencies, as shown in Fig. 2.

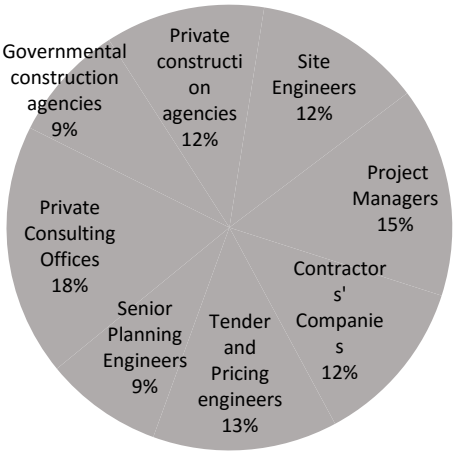

Fig. 2. Percentage of respondent candidates

The verbal evaluations of the respondent candidates are compiled and given their fuzzy equivalent values. Afterward, by following fuzzy rules, the crisp value of each factor has been calculated, resulting in seven main factors with different crisp values that exceed the predetermined threshold, as indicated in Table 3.

Table 3. The most important seven factors with their crisp values

Group Factor	Factors	Crisp value
Past Performance	Compliance with specifications and quality standards	0.73
	Past failure (failure to have a contract completed)	0.76
Past Experience	Types of projects completed	0.73
	scale of projects completed	0.71
	experience of contractor in constructing similar structures	0.72
Financial Capabilities	financial stability and risk prevention skills	0.71
Management Capability	ability to timely complete projects with workload	0.73

Those factors have been sorted into four key categories:

(1) Past Performance: Considering the business precedent of each contractor, the project manager will have a certain degree of confidence in the potential contractors' ability to meet the quality requirements.

(2) Past Experience: The contractor must provide information on their involvement in prior projects, with clarification of their scope and magnitude, especially whether they are similar to the one that will be carried out.

(3) Financial Capabilities**:** In the pre-qualification and bid evaluation stages, the main objective of the financial analysis is to determine the applicants' likelihood of delivering the project to the client's requirements, as their accounts would need to be carefully examined to identify their profitability, liquidity, stability, asset strength, and payment history.

(4) Management Capability: The contractor must establish, with his subsequent completed projects within the agreed period, that he is prepared to handle his workload and apply an effective planning and controlling system.

So, compared to each other, past failure is the most effective factor with an initial relative weight of 100%, followed by the ability to timely complete projects with the workload, compliance with specifications and quality standards, and types of projects completed with a 96.05%. Then, the experience of a contractor in similar structures scored 94.74%, and finally, the scale of projects completed, and financial stability and risk prevention skills scored the same 93.42%.

5. Conclusions

In order to provide methods for evaluating the criteria against the owner's goals for the tendering process, it is necessary to clarify and develop the predetermined selection factors. And this is what has been concluded in this paper by a detailed literature review and a fuzzy Delphic study of a selected sample of construction professionals with experience in prequalification and execution procedures. This paper reflects the point of view of the Egyptian construction marketer. It primarily considered four essential groups, indicating the most important factors, including: (1) Past performance: reviewing the contractor's history of both successful projects that had been completed within budget, time, and of course, the quality specified, as well as non-completed contracts and specifying reasons for failure; (2) Past experience: indicating how well the contractor handled previous projects that are similar to the upcoming project to be executed. In addition to the overall company's track record, which includes all types of projects that have been constructed with full information, including their costs; (3) Financial capabilities: investigating the contractor's financial ability to complete previous contracts without distress or bankruptcy and his professionalism in developing plans to overcome any financial problem and prevent the risks involved and implementing those plans in reality; (4) Management capabilities: resulting in project completion on time with a workload that needs a huge amount of ability in planning, organizing, coordinating, and controlling all project aspects.

6- Recommendations

This research's results can be a useful data base for the construction industry market, including clients as well as contractors; for clients, it reviews their current prequalification procedure and provides recommendations for improvements to the tender assessment process. As for contractors, they will benefit from a better understanding of market aspects and a focus on their clients' needs. Also, despite being conducted in Egypt, the study is helpful to professionals seeking to undertake construction projects throughout the Middle East's developing region due to the shared patterns in core disciplines.
It is recommended that the findings of this study be used as a basic first step for any Egyptian researcher developing a model for selecting contractors after appropriately assessing those factors.

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