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An AHP Model for Construction Contractor Prequalification

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Abstract
Contractor prequalification, i.e. the elimination of incompetent contractors from the bidding process according to a predetermined set of criteria, is a frequently used procedure of selecting contractors, because it seems to minimize risks and failures. In this paper a model based on the Analytic Hierarchy Process (AHP) is proposed for contractor prequalification, which is: a/ Complete, in the sense that various criteria are included, in order on the one hand to ensure the quality of the completed product and, on the other hand, to avoid contractors bankruptcies quite often due to the lowest tender price methods, or bargains between applicants. b/ Easy to use, in the sense, first, that it requires no prior knowledge of multicriteria methods from the potential users; and, second, it minimizes subjective judgments, since state administrators having to be accountable for their decisions dislike the use of ambiguous evaluation criteria.

Keywords
AHP, Bid evaluation, Contractor selection, Multicriteria analysis, Prequalification

1. Introduction

Worldwide four procedures are currently utilized for contractor selection (Palaneeswaran and Kumaraswamy, 2001; Topcu, 2004): i/ Open tendering. ii/ Selective/restricted tendering. iii/ Prequalification. iv/ Negotiation. In this paper we are dealing with the prequalification. i.e. the elimination of incompetent contractors from the bidding process according to a predetermined set of criteria.
Ng and Skitmore (1999) have investigated the divergence of decision criteria used by different client and consultant organizations in contractor prequalification through a large empirical survey conducted in the UK and their results indicate that there are significant differences in the selection and use of decision criteria for prequalification. Holt et al. (1995), after suggesting that in any case an effective selection approach should integrate prequalification as part of any selection exercise, introduce a standard secondary investigative procedure for evaluation of contractors, combine the latter with the total tender cost to generate a final combined score and thus recommend the most eligible (compromised) bidder. Reviewing a representative sample of the existing literature, Fong et al. (2000) found eleven models of prequalification and four models for final contractor selection. Russell and Skibniewski (1988) mention five prevailing methods that are in use for contractor prequalification: dimensional weighting, two-step prequalification,

dimension-wide strategy, prequalification formula, and subjective judgment. Based on contractor selection practices of various public project owners in different countries, Palaneeswaran and Kumaraswamy (2001) developed a model for contractor prequalification that uses three groups of criteria (responsiveness, responsibility and competency). Recently, multicriteria methods have been also proposed. Hatush and Skitmore (1998) present a method for contractor selection and bid evaluation based on multicriteria utility theory that combines the advantages of scoring techniques and optimization models. Fong and Choi (2000) and Anagnostopoulos et al. (2004) propose models based on the Analytic Hierarchy Process (AHP) for final contractor selection. Al-Subhi Al-Harbi (2001) uses contractor prequalification as an example of using AHP in project management and Topcu (2004) proposes a decision model using also AHP for construction contractor selection practices of project owners in the public sector.

This paper proposes an AHP model for construction contractor prequalification. The prequalification procedure in Greece, imposed by law 1418/84, is used for projects of great importance in which special expertise is required (Gerontas, 2000). After a preliminary screening based on mandatory requirements, the interested applicants are evaluated and a short list of no less than five and more than twenty tenders (C-225/98) is formed, and the short-listed applicants are invited for bidding. The multicriteria model used for forming the short list has three main advantages. The model is: a/ Complete, in the sense that various criteria are included (financial stability, know-how etc.), in order on the one hand to ensure the quality of the completed product and, on the other hand, to avoid contractors bankruptcies quite often due to the lowest tender price methods, or bargains between applicants. b/ Easy to use, in the sense, first, that it requires no prior knowledge of multicriteria methods from the potential users; and, second, it minimizes subjective judgments, since state administrators having to be accountable for their decisions dislike the use of ambiguous evaluation criteria. c/ Minimize the required pairwise comparisons, which is considered to be a major default of AHP.

2. The proposed model

AHP is a well-known multicriteria method for dealing with complex decision-making problems in which many competing alternatives (projects, actions, scenarios) exist (Saaty and Vargas, 1994; Saaty, 1990; Saaty, 1995; Vargas, 1990). The alternatives are ranked using several quantitative and/or qualitative criteria, depending on how they contribute in achieving an overall goal. AHP is based on a hierarchical structuring of the elements that are involved in a decision problem. The hierarchy incorporates the knowledge, the experience and the intuition of the decision-maker for the specific problem. The hierarchy evaluation is based on pairwise comparisons in which the decision-maker compares two alternatives using a criterion and assigns a numerical value to their relative weight.

Five levels form the hierarchy (Fig. 1). The goal of the hierarchy, the optimal ranking of tenders, is placed on the first level, while the second consists of the four principal criteria that describe the financial (Crit. 1) and technical (Crit. 2) performances of a firm, its policy regarding to health and safety (Crit. 3) and its performance in the construction of public works (Crit. 4). Subcriteria, that are further specifications of the second level criteria, are placed on the third level of the hierarchy. In the model presented here only the technical performance criterion is divided into two subcriteria, namely, resources (Crit. 2.1) and experience (Crit. 2.2). Indicators are placed on the fourth level in order to evaluate the candidate contractors. Indicators are numbers that summarize the corresponding criterion. The lowest level of the hierarchy consists of the eligible contractors to be evaluated in order to rank them according to criteria. It must be noted that this is a generic model in the sense that, first, it is not specified if the value of an indicator, for example, is equal to its value in the last year or an average value; and, second, that additional indicators can easily be included in the hierarchy. The following indicators are included in the hierarchy:

1. Financial performance

Ind 1.1 Return on net worth ratio (earnings before interests and taxes/owner's equity)
Ind 1.2 Credit ratio (owner's equity/total assets)
Ind 1.3 Current ratio (current assets/current liabilities)
Ind 1.4 Asset turnover ratio (sales/total assets)
Ind 1.5 Ratio of fixed assets/long term liabilities
Ind 1.6 Firms growth (total turnover during the last three years (€))

2. Technical performance
2.1 Resources
Ind 2.1.1 Equipment owed by the contractor (€)
Ind 2.1.2 Employed engineers by each candidate (number)
Ind 2.1.3 Training programs for the personnel, funding by the tender (€)
2.2 Experience
Ind 2.2.1 Contractor's years in business (years)
Ind 2.2.2 Contractor's activity during the last three years (awarded contracts (€))
Ind 2.2.3 Candidates experience in similar projects (awarded contracts (€))

3. Health and safety policy:
Ind 3.1 Indemnities paid for labor accidents during the last five years (€)
Ind 3.2 Investment in health and safety (€)

4. Past performances in public works:
Ind 4.1 Schedule overruns at executed contracts (bid duration/final duration)
Ind 4.2 Cost overruns at executed contracts (bid price/final cost)
Ind 4.3 Attitude towards to claims (€)

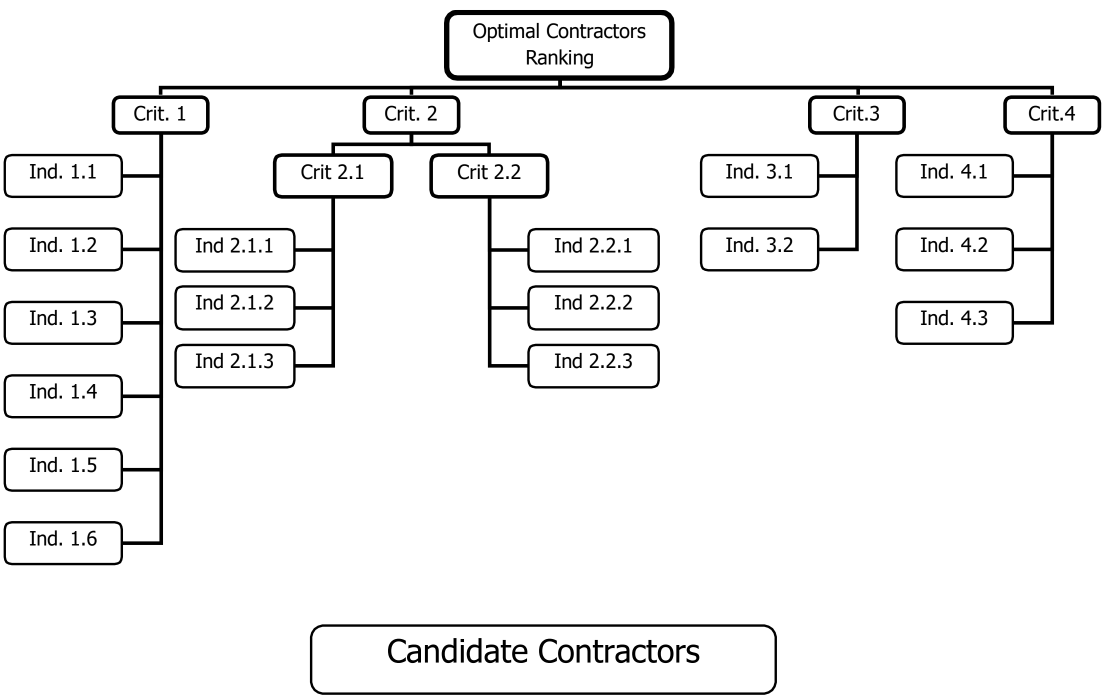

Figure 1: The prequalification hierarchy

3. Establishing priorities among the criteria

Priorities for the elements of the first three levels of the hierarchy are established via pairwise comparisons in evaluation matrices using the nine-point scale as suggested by Saaty (1995), that is, a 4×4 matrix for the second level criteria evaluation (Table 1), and a 2×2 matrix for the third level criteria (Table 2). Priorities for the second level criteria are calculated according to their relative importance for the hierarchy's goal, while the third level subcriteria are evaluated according to their relative importance for the technical performance criterion (Table 2). Indicators are also evaluated according to their relative importance regarding to the criteria they belong and five matrices are formed for this purpose (i.e. indexes 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6 with respect to first criterion). Eligible contractors (nine in our example) are ranked according to their performance for the proposed indicators by forming eighteen matrices. Table 3 shows priorities estimation among the alternatives (contractors) for the number of the employed engineers by the candidate contractors. Finally, local priorities are normalized and the contractors overall priorities are established (Table 4).

Table 1: Deriving priorities (level 2)

Deriving Priorities: Second Level Criteria							**C.R.**
	Crit. 1	**Crit. 2**	**Crit. 3**	**Crit. 4**	**Priorities**		
Crit. 1	1	1	2	4	**Crit. 1**	0.361	0.07
Crit. 2	1	1	3	4	Crit. 2	0.389	
Crit. 3	1/2	1/3	1	1/2	Crit. 3	0.118	
Crit. 4	1/4	1/4	2	1	Crit. 4	0.132	

Table 2: Deriving priorities (level 3)

Deriving Priorities: Third Level Criteria					**C.R.**
	Crit. 2.1	**Crit. 2.2**	**Priorities**		0
Crit. 2.1	1	1,5	**Crit. 2.1**	0,6	
Crit. 2.2	1/1,5	1	**Crit. 2.2**	0,4	

Table 3: Deriving priorities (level 4, Ind 2.2.1)

Deriving Priorities for the Ind 2.2.1										
Crit. 2.2.1	**Employed Engineers by the Candidate Contractors**									
Data	6	6	7	8	4	5	7	5	4	
Contractors	**Contr 1**	**Contr 2**	**Contr 3**	**Contr 4**	**Contr 5**	**Contr 6**	**Contr 7**	**Contr 8**	**Contr 9**	**Priorities**
Contr 1	1	6/6	6/7	6/8	6/4	6/5	6/7	6/5	6/4	**0.115**
Contr 2	6/6	1	6/7	6/8	6/4	6/5	6/7	6/5	6/4	**0.115**
Contr 3	7/6	7/6	1	7/8	7/4	7/5	7/7	7/5	7/4	**0.135**
Contr 4	8/6	8/6	8/7	1	8/4	8/5	8/7	8/5	8/4	**0.154**
Contr 5	4/6	4/6	4/7	4/8	1	4/5	4/7	4/5	4/4	**0.077**
Contr 6	5/6	5/6	5/7	5/8	5/4	1	5/7	5/5	5/4	**0.096**

Contr 7	7/6	7/6	7/7	7/8	7/4	7/5	1	7/5	7/4	**0.135**
Contr 8	5/6	5/6	5/7	5/8	5/4	5/5	5/7	1	5/4	**0.096**
Contr 9	4/6	4/6	4/7	4/8	4/4	4/5	4/7	4/5	1	**0.077**

Since it is rather difficult to deal with inconsistency in pairwise comparisons matrices with dimension more than 9×9 (Saaty, 1995), the number of the alternatives should not be more than nine. The method provides two options depending on the number of alternatives. a/ *Less than nine alternatives***:** In this case the number of the evaluation matrices for the alternatives equals the number of the subcriteria of the level just above the alternatives. In our example seventeen matrices are formed. Each matrix requires thirty six weights to be supplemented by the decision maker. b/ *More than nine***:** In this case alternatives are evaluated using a rating scale for each subcriterion, that is, a rating scale is assigned to each subcriterion related to every alternative. Then priorities are determined with respect to the intensity scoring assigned to each alternative (Anagnostopoulos et al. 2004). Since in our model the evaluation of contractors is based on ratios of quantitative indicators, matrices of any dimension can be formed because there is no need for consistency measurement. Moreover, no judgments by the decision makers are required.

Table 4: Deriving local and global priorities for the hierarchy's criteria

Criteria	Normalized eigenvectors	Composite Relative Priorities	**Criteria**	Normalized eigenvectors	Composite Relative Priorities	**Criteria**	Normalized eigenvectors	Composite Relative Priorities	**Index Priorities**
Crit. 1	0,361	0,361	**Crit. 1.1**	0,150	0,054				**0,054**
			Crit. 1.2	0,150	0,054				**0,054**
			Crit. 1.3	0,212	0,077				**0,077**
			Crit. 1.4	0,269	0,097				**0,097**
			Crit. 1.5	0,109	0,039				**0,039**
			Crit. 1.6	0,109	0,039				**0,039**
Crit. 2	0,389	0,389	**Crit. 2.1**	0,600	0,233	**Crit. 2.1.1**	0,407	0,095	**0,095**
						Crit. 2.1.2	0,370	0,086	**0,086**
						Crit. 2.1.3	0,224	0,052	**0,052**
			Crit. 2.2	0,400	0,156	**Crit. 2.2.1**	0,225	0,035	**0,035**
						Crit. 2.2.2	0,281	0,044	**0,044**
						Crit. 2.2.3	0,464	0,072	**0,072**
Crit. 3	0,118	0,118	**Crit. 3.1**	0,667	0,079				**0,079**
			Crit. 3.2	0,333	0,039				**0,039**
Crit. 4	0,132	0,132	**Crit. 4.1**	0,455	0,060				**0,060**
			Crit. 4.2	0,199	0,026				**0,026**
			Crit. 4.3	0,347	0,046				**0,046**

Table 5: Contractors final ranking

	Ind Priorities	**Composite Relative Priorities**								
		Contr 1	**Contr 2**	**Contr 3**	**Contr 4**	**Contr 5**	**Contr 6**	**Contr 7**	**Contr 8**	**Contr 9**
Ind 1.1	0,054	0,009	0,007	0,007	0,006	0,004	0,006	0,004	0,007	0,004
Ind 1.2	0,054	0,010	0,006	0,006	0,003	0,006	0,006	0,003	0,003	0,010

Ind 1.3	0,077	0,008	0,008	0,010	0,010	0,005	0,010	0,013	0,005	0,008
Ind 1.4	0,097	0,013	0,013	0,013	0,009	0,011	0,011	0,007	0,009	0,009
Ind 1.5	0,039	0,004	0,004	0,004	0,005	0,004	0,006	0,004	0,004	0,004
Ind 1.6	0,039	0,004	0,004	0,005	0,004	0,003	0,003	0,005	0,005	0,005
Ind 2.1.1	0,095	0,012	0,009	0,012	0,009	0,009	0,012	0,006	0,012	0,015
Ind 2.1.2	0,086	0,008	0,008	0,010	0,008	0,008	0,011	0,011	0,010	0,010
Ind 2.1.3	0,052	0,006	0,006	0,006	0,006	0,007	0,004	0,007	0,004	0,004
Ind 2.2.1	0,035	0,004	0,004	0,005	0,005	0,003	0,003	0,005	0,003	0,003
Ind 2.2.2	0,044	0,004	0,005	0,004	0,004	0,005	0,005	0,006	0,006	0,004
Ind 2.2.3	0,072	0,010	0,007	0,010	0,007	0,007	0,007	0,010	0,010	0,007
Ind 3.1	0,079	0,011	0,008	0,008	0,008	0,007	0,007	0,008	0,011	0,011
Ind 3.2	0,039	0,006	0,004	0,004	0,004	0,005	0,005	0,006	0,004	0,004
Ind 4.1	0,060	0,008	0,008	0,008	0,008	0,004	0,004	0,004	0,008	0,008
Ind 4.2	0,026	0,002	0,002	0,002	0,002	0,005	0,005	0,005	0,002	0,002
Ind 4.3	0,046	0,008	0,008	0,008	0,004	0,004	0,003	0,003	0,003	0,003
	Total	**0,125**	**0,111**	**0,123**	**0,103**	**0,098**	**0,108**	**0,109**	**0,108**	**0,110**
	Rank	**1st**	**3rd**	**2nd**	**8th**	**9th**	**6th**	**5th**	**7th**	**4th**

4. Conclusions

The procedures followed by the authorities until now have been accused, at least in Greece, for lack of credibility. This paper proposes an AHP based model for contractor prequalification. The AHP is chosen for its simplicity and transparency in multicriteria choice situations. The short-listing of bidders via indicators instead of qualitive criteria rapidly decreases the need for weights assigment by the authorities and increases the impartiality of the final choice. For instance, in our example, the required judgments from the decision makers are only thirty two, while 644 judgments are needed in a model with the same hierarchy's structure but consisting of qualitative criteria. The addition of quantitative subcriteria generates no difficulties and/or of a few qualitative subcriteria on the third level does not increases dramatically the number of the needed pairwise comparisons. Therefore, the proposed model is sufficiently flexible to meet requirements of decision makers.

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