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An AHP Model for Construction Contractor Prequalification

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Abstract

Given that contractor plays a critical role in any construction project, contractor selection constitutes key decision for public authorities. Prequalification, i.e. the elimination of incompetent contractors from the bidding process according to a predetermined set of criteria, is a frequently practiced procedure in many countries, including Greece. In order to enhance the performance levels of selected contractors and to minimize failures in meeting client's objectives, several criteria must be taken into account and a consistent evaluation methodology must be applied. We propose a multicriteria decision making approach, based on the Analytic Hierarchy Process (AHP), for supporting public authorities in contractor prequalification. The decision problem is decomposed into qualitative criteria and sub-criteria that are further analyzed in quantitative indicators on which the candidate contractors are evaluated. Our advisory decision support system is an appropriate tool for at least three reasons: First, various criteria are included, in order to ensure the quality of the completed product. Second, it is easy to use, because, on the one hand, it requires no prior knowledge of multicriteria methods from the potential users; and, on the other hand, it minimizes subjective judgments. Finally, the model minimizes the required pairwise comparisons, which is considered to be a major default of AHP.

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

1. Introduction

The prequalification procedure, i.e. the elimination of incompetent contractors from the bidding process according to a predetermined set of criteria, is one of the currently utilized procedures worldwide for contractor selection [Palaneeswaran and Kumaraswamy (2001), Topcu (2004)]. Since "it is increasingly recognized that the lowest bid is not necessarily the most economical solution in the long term" [Kumaraswamy (1996)], both the selected criteria and a sound evaluation methodology are essential factors in any contractor selection procedure, including prequalification, in order to assure the ability of selected contractor to achieve simultaneously time, cost, and quality specifications.

The prequalification procedure in Greece, imposed by law 1418/84, article 4, paragraph 2β, 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 is formed, and the short-listed applicants are invited for bidding. Especially, the prequalification procedure is carried out in five stages: In the first stage an invitation for tendering is made. In the second stage the interested applicants, that fulfill the owner/client's requirements prescribed on the announcement, submit their applications. In the third stage, public authorities select on specified criteria potential contractors. In the fourth stage the short listed contractors are submit their price offers, and in the last stage the winner contractor is selected.

We suggest a multicriteria approach for construction contractor prequalification, based on the Analytic Hierarchy Process (AHP), a well known multicriteria method [Saaty and Vargas (1994), Saaty (1990), Saaty (1995), Vargas (1990)]. In particular, we propose an AHP model for forming the short list of tenders (the third of the aforesaid stages). The decision problem is decomposed into qualitative criteria and subcriteria that are further analyzed in quantitative indicators on which the candidate contractors are evaluated. Our model is a suitable decision support system for three main reasons: a/ It is 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/ It is 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/ It minimizes the required pairwise comparisons, which is considered to be a major default of AHP, in general, and of the proposed models in the literature in particular. Moreover, the model is sufficiently flexible given that decision makers may add new indicators and/or a few qualitative subcriteria without considerably increase the needed pairwise comparisons.

Note that this paper is focused on a project specific prequalification. However, our model may be adapted with no major changes to cover also prequalification in a broader sense, i.e. "registration" of eligible contractors classified according to their work capacities on a list retained/updated by public bodies [Palaneeswaran and Kumaraswamy (2001)].

Following this introduction, the literature on contractor evaluation and selection procedures will be briefly reviewed, and a summary of the AHP multicriteria method will be given. Then the proposed model is developed and discussed with regard to why it is a suitable tool for contractor prequalification. A hypothetical example illustrates the application of the evaluation procedure. After that the conclusion follows.

2. Literature review

Contractor prequalification and bid evaluation are multicriteria group decision making processes. They involve the consideration of a broad range of decision criteria as well as the participation of many decision makers [Russell and Skibniewski, 1988].

Table 1. *Contractor selection models*

Aggregated weighing	Russell and Skibniewski (1990)
Analytic Hierarchy Process (AHP)	Al-Subhi Al-Harbi (2001), Anagnostopoulos et al. (2004), Fong and Choi (2000), Topcu (2004)
Bespoke approach	Holt (1998)
Cluster analysis	Holt (1996), Holt (1998)
Contractor prequalification based on three groups of criteria	Palaneeswaran and Kumaraswamy (2001)
Dimensional weighting	Russell and Skibniewski (1988), Sönmez et al. (2002)
Dimensional-wide strategy	Russell and Skibniewski (1988), Sönmez et al. (2002)
Evidential Reasoning	Sönmez et al. (2002)
Fuzzy sets model	Nguyen (1985), Lin and Chen (2004)
General Performance Model	Alacrón and Mourges (2002)
Knowledge-intensive model	Russell et al. (1990)
Multi-attribute analysis	Holt et al. (1995b)
Multi-attribute utility theory	Hatush and Skitmore (1998)
Multiple regression method	Holt (1998)
Multivariate discriminant analysis	Holt (1998), Skitmore and Marsden (1988)
Performance Assessment Scoring System (PASS)	Kumaraswamy (1996)
Prequalification formula	Russell and Skibniewski (1988), Sönmez et al. (2002)
Risk analysis	Jaselskis and Russell (1992)
Simplified quality assessment	RICS (1997)
Subjective judgment	Russell and Skibniewski (1988), Sönmez et al. (2002)
Two-step prequalification	Russell and Skibniewski (1988), Sönmez et al. (2002)

Several criteria and evaluation methodologies have been proposed in the last two decades. The fundamental rationale behind this research is a growing realization that the widely used lowest tender price criterion is insufficient, and then the quality of eligible contractors must be taken into account. Table 1 summarizes the models for contractor selection proposed in the literature.

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. A great deal of research was devoted to identify commonly used criteria for prequalification and bid evaluation [Alsugair (1999), Hatush and Skitmore (1997), Jaselskis and Russell (1992), Kumaraswamy (1996), Ng and Skitmore (1999), Russell and Skibniewski (1988)]. Hatush and Skitmore (1997) classified into five groups the information used for the assessment of criteria for prequalification and bid evaluation: general information that is used mainly for administrative purposes, financial information, technical information, managerial information and safety information.

Holt et al. (1995c), 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. 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. Reviewing a representative sample of the existing literature, Fong and Choi (2000) found eleven models of prequalification and four models for final contractor selection. 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, multiple criteria decision analysis (MCDA) models 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. Anagnostopoulos et al. (2004) propose an AHP model for contractor selection in open tendering. An eligible contractor is evaluated via a seven-point rating scale (unacceptable, very poor, poor, average, good, very good and outstanding) assigned to each sub-criterion. Although this rating scale reduces considerably the required pairwise comparisons, it does not assure the impartiality of judgments. Contractor selection can be roughly divided into two stages: prequalification and final selection. The AHP model proposed by Fong and Choi (2000) is aimed at the latter stage, i.e. selecting a contractor to whom to award a contract. Since the hierarchy contains 15 evaluation criteria (including the tender price), if 9 bids are to be evaluated, at least 36 × 15 = 540 judgments must be made. Topcu (2004) proposes a complex decision model that contains two separated hierarchies. The first hierarchy is used for the construction contractor prequalification (10 criteria) and the second one for final selection (a bicriteria, benefit and cost, decision model). The decision model uses ratings that are obtained through a transformation mechanism and a filtering process based on predefined or calculated threshold values. Finally, Al-Subhi Al-Harbi (2001) presents the Analytical Hierarchy Process (AHP) "as a potential decision making method for use in project management". Since "the contractor prequalification problem is used as an example" only six criteria are retained and the hierarchy evaluation is performed with the standard AHP procedure.

3. The Analytic Hierarchy Process (AHP)

Developed by T.L. Saaty, the Analytic Hierarchy Process (AHP) is a multicriteria decision aiding method based on a solid axiomatic foundation. AHP is a systematic procedure for dealing with complex decision making problems in which many competing alternatives (projects, actions, scenarios) exist [Forman and Selly (2002), 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.

Table 2. *Pairwise comparison matrix A of alternatives P_i with respect to criterion K*

K	P_1	P_2	$\cdots$	P_n
P_1	1	a_{12}	...	a_{1n}
P_2	$1/a_{12}$	1	...	a_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
P_n	$1/a_{1n}$	$1/a_{2n}$	...	1

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 simplest hierarchy consists of three levels. On the top of the hierarchy lies the decision's goal. On the second level lie the criteria by which the alternatives (third level) will be evaluated. In more complex situations, the main goal can be broken down into subgoals or/and a criterion (or property) can be broken down into sub-criteria. People who are involved in the problem, their goals and their policies can also be used as additional levels.

The hierarchy evaluation is based on pairwise comparisons. The decision maker compares two alternatives A_i and A_j with respect to a criterion and assigns a numerical value to their relative weight. The result of the comparison is expressed in a fundamental scale of values ranging from 1 (A_i, A_j contribute equally to the objective) to 9 (the evidence favoring A_i over A_j is of the highest possible order of affirmation). Given that the *n* elements of a level are evaluated in pairs using an element of the immediately higher level, an *n×n comparison matrix* is obtained (Table 2). If the immediate higher level includes *m* criteria, *m* matrixes will be formed. In every comparison matrix all the main diagonal elements are equal to one ($a_{ii} = 1$) and two symmetrical elements are reciprocals of each other ($a_{ij} \times a_{ji} = 1$).

Since *n(n-1)/2* pairwise comparisons are required to complete a comparison matrix, *mn(n-1)/2* judgments must be made to complete the evaluation of the n elements of a level using as criterion the m elements of the immediately higher level. For large evaluations, the number of comparisons required by the AHP can be somewhat of a burden. For example, if 5 bids are to be evaluated, in a model containing 20 criteria, at least 10 × 20 = 200 judgments must be made.

The decision-maker's judgments may not be consistent with one another. A comparison matrix is consistent if and only if $a_{ij} \times a_{jk} = a_{ik}$ for all i, j, k. AHP measures the inconsistency of judgments by calculating the *consistency index CI* of the matrix

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

where λ_{max} is the principal eigenvalue of the matrix.

The consistency index CI is in turn divided by the *average random consistency index* RI to obtain the *consistency ratio* CR.

$$CR = \frac{CI}{RI}$$

The RI index is a constant value for an n×n matrix, which has resulted from a computer simulation of *n×n* matrices with random values from the 1-9 scale and for which $a_{ij} = 1/a_{ji}$. If CR is less than 5% for a 3×3 matrix, 9% for a 4×4 matrix, and 10% for larger matrices, then the matrix is consistent.

Once its values are defined, a comparison matrix is normalized and the local priority (the relative dominance) of the matrix elements with respect to the higher level criterion is calculated. The overall priority of the current level elements is calculated by adding the products of their local priorities by the priority of the corresponding criterion of the immediately higher level. Next, the overall priority of a current level element is used to calculate the local priorities of the immediately lower level which use it as a criterion, and so on, till the lowest level of the hierarchy is reached. The priorities of the lowest level elements (alternatives) provide the relative contribution of the elements in achieving the overall goal.

Note that the AHP also allows group decision making. Each member of the group provides separately his own judgments according to his experience, values and knowledge. If the group has achieved consensus on some judgment, only that judgment is registered. If during the process it is impossible to arrive at a consensus on a judgment, the group may use some voting technique, or may choose to take the "average" of the judgments, that is the geometric mean of the judgments. The group may decide to give all group members equal weight, or the group members could give them different weights that reflect their position in the project.

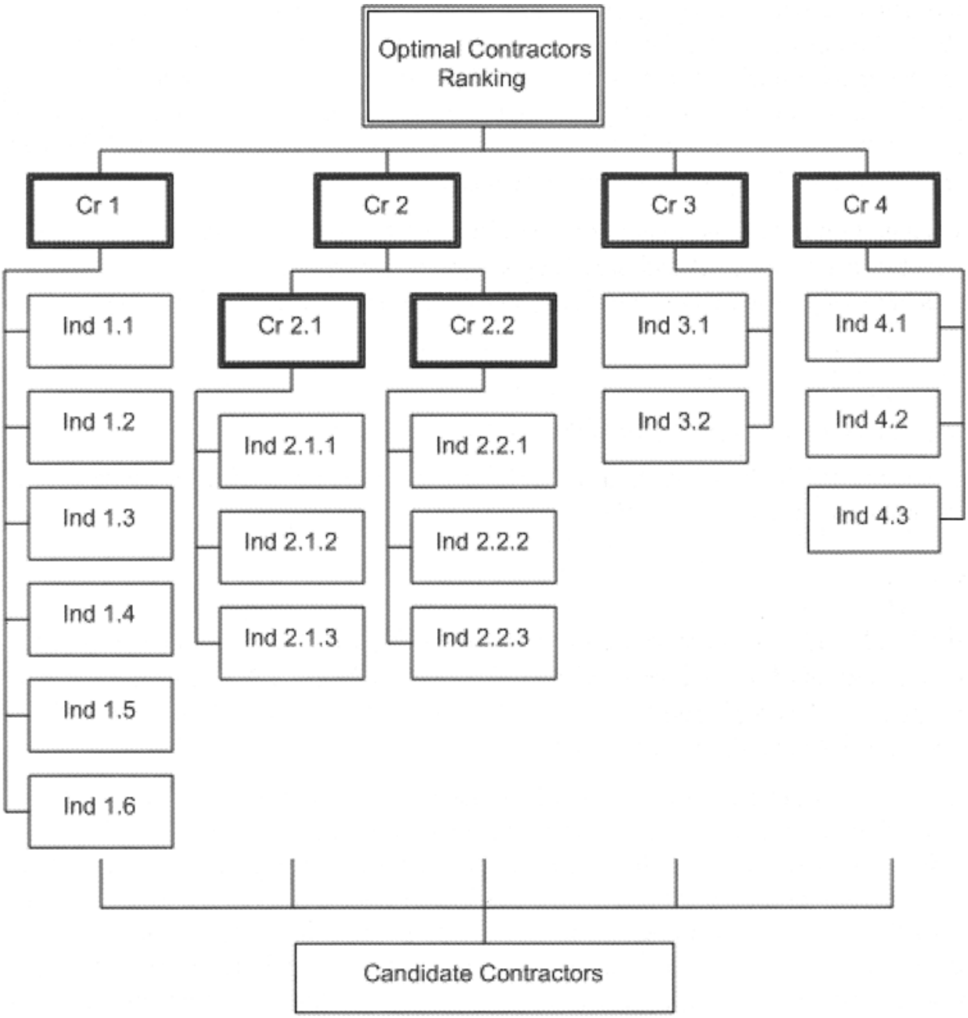

Figure 1. *The prequalification hierarchy*

4. The development of the AHP model

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 (Cr 1) and technical (Cr 2) performances of a firm, its policy regarding to health and safety (Cr 3) and its performance in the construction of public works (Cr 4). Sub-criteria, 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 sub-criteria, namely, resources (Cr 2.1) and experience (Cr 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 (€)

5. 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 3), and a 2×2 matrix for the third level criteria (Table 4). Priorities for the second level criteria are calculated according to their relative importance for the hierarchy's goal, while the third level sub-criteria are evaluated according to their relative importance for the technical performance criterion (Table 4). Indicators are also evaluated according to their relative importance regarding to the criteria they belong and five matrices are formed for this purpose (e.g. indicators 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6 with respect to first criterion).

Table 3. *Deriving priorities (level 2)*

Deriving Priorities: Second Level Criteria							**CR**
	Cr 1	**Cr 2**	**Cr 3**	**Cr 4**	**Priorities**		
Cr 1	1	1	2	4	Cr 1	0,361	0,07
Cr 2	1	1	3	4	Cr 2	0,389	
Cr 3	1/2	1/3	1	1/2	Cr 3	0,118	
Cr 4	1/4	1/4	2	1	Cr 4	0,132	

Table 4: *Deriving priorities (level 3)*

Deriving Priorities: Third Level Criteria					**CR**
	Cr 2.1	**Cr 2.2**	**Priorities**		
Cr 2.1	1	1,5	**Cr 2.1**	0,6	0
Cr 2.2	1/1,5	1	**Cr 2.2**	0,4	

Eligible contractors (nine in our example) are ranked according to their performance for the proposed indicators by forming eighteen matrices. Table 5 shows priorities estimation among the alternatives (contractors) with respect to the number of the employed engineers by the candidate contractors. It must be noted that the priority with respect to the criterion 2.1.2 for each company (and for the other indicators as well) can also be calculated as the ratio of the number of its engineers to the sum of all engineers from all companies (the software package Expert Choice supports both methods). Finally, local priorities are normalized and global priorities for the criteria are derived (Table 6), and the contractors final ranking is obtained according to their contribution to the hierarchy's goal (Table 7).

***Table 5:** Deriving priorities (level 4, Ind 2.2.1)*

Deriving Priorities for the Ind 2.1.2										
Ind 2.2.1	**Employed Engineers by the Candidate Contractors**									
Data	6	6	7	8	4	5	7	5	4	
Contractors	**Con 1**	**Con 2**	**Con 3**	**Con 4**	**Con 5**	**Con 6**	**Con 7**	**Con 8**	**Con 9**	**Priorities**
Con 1	1	6/6	6/7	6/8	6/4	6/5	6/7	6/5	6/4	**0,115**
Con 2	6/6	1	6/7	6/8	6/4	6/5	6/7	6/5	6/4	**0,115**
Con 3	7/6	7/6	1	7/8	7/4	7/5	7/7	7/5	7/4	**0,135**
Con 4	8/6	8/6	8/7	1	8/4	8/5	8/7	8/5	8/4	**0,154**
Con 5	4/6	4/6	4/7	4/8	1	4/5	4/7	4/5	4/4	**0,077**
Con 6	5/6	5/6	5/7	5/8	5/4	1	5/7	5/5	5/4	**0,096**
Con 7	7/6	7/6	7/7	7/8	7/4	7/5	1	7/5	7/4	**0,135**
Con 8	5/6	5/6	5/7	5/8	5/4	5/5	5/7	1	5/4	**0,096**
Con 9	4/6	4/6	4/7	4/8	4/4	4/5	4/7	4/5	1	**0,077**

***Table 6:** Deriving local and global priorities for the hierarchy's criteria*

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

Table 7: *Contractors final ranking*

	Ind Priorities	Composite Relative Priorities								
		Con 1	**Con 2**	**Con 3**	**Con 4**	**Con 5**	**Con 6**	**Con 7**	**Con 8**	**Con 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*	0,010	0,010	0,012	0,013	0,007	0,008	0,012	0,008	0,007
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*	0,003	0,003	0,004	0,003	0,003	0,005	0,005	0,004	0,004
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	0,126	0,112	0,123	0,105	0,096	0,106	0,109	0,106	0,108
	Rank	**1st**	**3rd**	**2nd**	**8th**	**9th**	**7th**	**4th**	**6th**	**5th**

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.

- *Less than nine alternatives:* In this case the number of the evaluation matrices for the alternatives equals the number of the sub-criteria of the level just above the alternatives. In our example seventeen matrices are formed. Each matrix requires thirty six weights, i.e. values of indicators, to be supplemented by the decision maker.
- *More than nine alternatives:* In this case alternatives are evaluated using a rating scale for each sub-criterion, that is, a qualitative rating scale is assigned to each sub-criterion related to every alternative. Then priorities are determined with respect to the intensity scoring assigned to each alternative [Anagnostopoulos et al. (2004)]. This evaluation procedure necessitates also judgments from the decision makers.

Given that in our model the evaluation of contractors is based on ratios of quantitative indicators, matrices of any dimension can be formed because every matrix is strongly consistent since $a_{ik} \times a_{kj} = a_{ij}$ for all *i*, *j*, *k*, where a_{ij} is the ratio of the attribute w_i of the alternative *i* by the attribute w_j of the alternative *j* respectively [Forman and Selly (2002)]. Moreover, no judgments by the decision makers are required.

The short-listing of bidders via indicators instead of qualitative criteria rapidly decreases the need for weights assignment 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.

Finally, the proposed method, by combining qualitative and quantitative criteria in a hierarchy, contributes to the rationalization of the whole decision process. The structuring of a decision problem in a hierarchy has been proved to be the most effective way to deal with complexity [Saaty (1995), Simon (1996)]. Furthermore, a direct assessment, i.e. establishing directly the relative weights based on expert judgment, does not assure consistencies in expert judgements, and this problem becomes even worst if additional qualitative criteria and sub-criteria are taken into account.

6. Conclusions

This paper proposes an AHP based model for contractor prequalification. The use of a solid multicriteria method contributes to the rationalization of the whole decision process. The AHP is chosen for its simplicity and transparency in multicriteria choice situations. Furthermore, many real world applications have proved that AHP is valuable tool for dealing with complex issues because it allows the decision makers to decompose hierarchically the decision problem to its constituent parts.

The decision criteria are arranged into a four levels hierarchy. The optimal ranking of tenders was decomposed into four principal criteria, the third level contains the sub-criteria, that are further specifications of the second level criteria, and the fourth level contains indicators on which the candidate contractors are evaluated.

Our principal aims were, on the one hand, the minimization of the required pairwise comparisons, which is considered to be a major default of AHP in general, and of the proposed models in the literature in particular, and the increase of impartiality in expert judgments. These are achieved by using indicators instead of qualitative criteria for the short-listing of bidders.

On the other hand, the flexibility of the proposed model is assured since the addition of any indicators or quantitative sub-criteria poses no problem and of a few qualitative sub-criteria on the second or the third level does not increase dramatically the number of the needed pairwise comparisons. Note that, in practice, detailed surveys may determine the suitable criteria and sub-criteria to be retained by the authorities as well as their weights. Finally, our model can be easily used in a group decision making environment by using the standard procedures of AHP.

The procedures followed by the authorities until now have been accused, at least in Greece, for lack of credibility. The use of a consistent evaluation methodology for contractor selection, in which several criteria are taken into account, may assure to a great extent the ability of selected contractor to achieve simultaneously time, cost, and quality specifications.

References

Alacrón L.F. and Mourges C. (2002). Performance modeling for contractor selection. Journal of Management in Engineering, 18(2), 52-60.

Al-Subhi Al-Harbi K.M. (2001). Application of the AHP in project management. International Journal of Project Management, 19, 19-27.

Alsugair A.M. (1999). Framework for evaluating bids of construction contractors. Journal of Management in Engineering, 15(2), 72–78.

Anagnostopoulos K.P., Gatsios N. and Vavatsikos A. (2004). Final contractor selection using a multicriteria methodology. In Proceedings of the 3rd Scientific Conference on Project Management, "Clustering in Construction Project Management", Editor: J.P. Pantouvakis (CD).

Fong P.S.-W. and Choi S.K.-Y. (2000). Final contractor selection using the Analytical Hierarchy Process. Construction Management and Economics, 18, 547–557.

Forman E.H. and Selly M.A. (2002). Decision by objectives. World Scientific Publications.

Gerontas A. (2000). Law of public works: The administrative contract of public work. A.N. Sakkoulas Editions, Athens-Komotini (in greek).

Hatush Z. and Skitmore M. (1997), Criteria for contractor selection. Construction Management and Economics, 15, 19-38.

Hatush Z. and Skitmore M. (1998). Contractor selection using multicriteria utility theory: An additive model. Building and Environment, 33(2-3), 105-115.

Holt G.D. (1996). Applying cluster analysis to contractor classification. Building and Environment, 31(6), 557-568.

Holt G.D. (1998). Which contractor selection methodology?. International Journal of Project Management, 16, No. 3, 153-164.

Holt G.D., Olomolaiye P.O. and Harris F.C. (1995a). Application of an alternative contractor selection model. Building Research and Information, 23(5), 255-264.

Holt G.D., Olomolaiye P.O. and Harris F.C. (1995b). Applying multi-attribute analysis to contractor selection decisions. European Journal of Purchasing and Supply Management, 1(3), 139–48.

Holt G.D., Olomolaiye P.O. and Harris F.C. (1995c). A review of contractor selection practice in the U.K. construction industry. Building and Environment, 30(4), 553-61.

Jaselskis E.J. and Russell J.S. (1992). Risk analysis approach to selection of contractor evaluation method. Journal of Construction Engineering and Management, 118(4), 814–821.

Kumaraswamy M.M. (1996). Contractor evaluation and selection: a Hong Kong perspective. Building and Environment, 31, No. 3, 273-282.

Lin C-T. and Chen Y-T. (2004). Bid/no-bid decision-making – a fuzzy linguistic approach. International Journal of Project Management, 22, 585–593.

Ng S.T. and Skitmore R.M. (1999). Client and consultant perspectives of prequalification criteria. Building and Environment, 34, 607-21.

Nguyen V.U. (1985). Tender evaluation by fuzzy sets. Journal of Construction Engineering and Management, 111, 231–243.

Palaneeswaran E. and Kumaraswamy M.M. (2001). Recent advances and proposed improvements in contractor prequalification methodologies. Building and Environment, 36, 73-87.

RICS (1997). The effect of competitive tendering on value in construction, RICS Research Paper Series, 2(5), Royal Institution of Chartered Surveyors, London.

Russell J.S. and Skibniewski M.J. (1988). Decision criteria in contractor prequalification. Journal of Management in Engineering, 4(2), 148-164.

Russell J.S. and Skibniewski M.J. (1990). Qualifier 1: Contractor prequalification model. Journal of Computing in Civil Engineering, 4(1), 77–90.

Russell J.S., Skibniewski M.J. and Cozier D.R. (1990). Qualifier 2: Knowledge based system for contractor prequalification. Journal of Construction Engineering and Management, 116(1), 157–71.

Saaty T.L. (1990). How to make a decision: The Analytic Hierarchy Process. European Journal of Operational Research, 48, 9-26.

Saaty T.L. (1995). Decision making for leaders, 3rd Edition. RWS Publications.

Saaty T.L. and Vargas L.G. (1994). Decision making with the Analytic Hierarchy Process. RWS Publications.

Simon H. A. (1996). The architecture of complexity. In The sciences of the artificial, MIT Press.

Skitmore R.M. and Marsden D.E. (1988). Which procurement system? Towards a universal procurement technique. Construction Management and Economics, 6, 71-89.

Sönmez M., Holt G.D., Yang J.B. and Graham G. (2002). Applying evidential reasoning to prequalifying construction contractors. Journal of Management in Engineering, 18(3), 111-119.

Topcu Y.I. (2004). A decision model proposal for construction contractor selection in Turkey. Building and Environment, 39, 469-81.

Vargas L.G. (1990). An overview of the Analytic Hierarchy Process and its applications. European Journal of Operational Research, 48(1), 2-8.