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Multi-Criteria Decision Making Approach in Contractor Selection

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Abstract

It is quite critical to select a qualified contractor because they have big influences upon projects and their successes. A competent construction contractor is one of the indispensable conditions of a proper process and completion of a construction project. There are several theoretical frameworks or models applied in the evaluation of contractors. In this paper, Analytic Hierarchy Process which is one of the most widely used multi-criteria decision making tools is used for contractor selection problem.

Keyword: Analytic Hierarchy Process, Contractor, Multi-Criteria Decision Making.

INTRODUCTION

In Turkey public administrators choose the contractors who awarded to the lowest bidder. This situation affects the quality of projects. In Public Procurement Law [1] all types of procurements is defined for public administrators. Before construction tender, public administrator researchs prices excluding value added tax to determine the approximate cost. After approximate cost is determined, according to the evaluation criteria specified in tender documents, tenderers are determined to satisfy the requirements of minimum criteria. Primarily qualified contractors submit their initial proposals that include technical details and realization methods of the subject matter without cost. Then tender commission meet each tenderer to determine the best appropriate way to meet the needs of administration. After the technical requirements are clarified, price quotations are taken from the tenderers. Administrator gives the work to contractor who perform with lowest price. In that method it has been concluded that the projects awarded to the lowest bidder have lower performance quality and schedule delays as compared to the projects which were awarded based on specific qualification criteria. So the new method is needed to perform a best construction. There are methods attempting to estimate the values of contractors by using various selection criteria. These methods include multi-criteria decision-making (MCDM), multi-attribute analysis (MAA), multi-attribute utility theory (MAUT), multiple regression (MR), cluster analysis (CA), bespoke approaches (BA), fuzzy set theory (FST) and multivariate discriminant analysis (MDA) [2, 3, 4,19].

Among those well-known methods, MCDM aims at using a set of criteria for a decision problem. Since these criteria may vary in the degree of importance, the analytic hierarchy process (AHP) technique is employed to prioritize the selection criteria [5]. In this paper the AHP approach is proposed as a tool to select the best contractor for a public work contact. The design of the AHP hierarchy must satisfy the goal of developing a model that will allow public administrators to decide which contractor is more appropriate for constructing the public buildings. Several factors considered to be relevant to the selection decision are used in the ranking of the qualification of construction. Public administrators are keen to choose an appropriate contractor because it could be a key for having a building success factor. When there are a lot of contractors are keen to build public buildings, public administrators need a guide in elimination of incompetent contractors from the bidding process. Thus this qualification guide can aid the administrators in achieving succesful and efficient desicion by ensuring that it is a qualified contractor who will construct the building. In completion of a project within the estimated cost and time is effected by the skill, capability and efficiency of contractor.

Qualification is defined by Moore [6], Clough [7] and Stephen [8] as the screening of construction contractors by project owners or their representatives according to apredetermined set of criteria deemed necessary for successful project performance, in order to determine the contractors' competence or ability to participate in the project bid. Russel and Skibniewski [9] also tried to describe the contractor qualification process along with the decision-making strategies and the factors that influence the process.

In decision making strategies the selection criteria and their weights are dependent on the decision maker. Firstly the decision maker gives the weights of selection criterias then all contractors are ranked on the basis of the criteria. A contractor's total score is calculated by summing their ranks multiplied by the weight of the respective criteria. Then, contractors are ranked on the basis of their total scores, and this rank order of the contractors is used for qualification.

Aitah [10] Al-Alawi [11] and Russel [12] studied on contractor qualification for public projects. In these studies they evaluated public building construction projects and concluded that the projects awarded to the lowest bidder have lower performance quality and schedule delays as compared to the projects which were awarded based on specific qualification criteria.

Al-Ghobali [13] surveyed the Saudi construction market and listed a number of factors against which contractors should be considered for qualification. This included experience, financial stability, past performance, current workload, management staff, manpower resources availability, contractor organization, familiarity with the project's geographic location, project management capabilities, quality assurance and control, previous failure to complete a contract, equipment resources, purchase expertise and material handling, safety consciousness, claim attitude, planning/scheduling and cost control, and equipment repairing and maintenance yard facilities [14].

Then Al-Harbi [14] studied in qualification of construction firms by using multi-criteria decision method. He determined six criteria for qualification and tried to select the best firm between the six contruction firms. The paper has presented the AHP as a decision-making method that allows the consideration of multiple criteria. An example of contractor prequalification was created to demonstrate AHP application in project management. Contractor prequalification involves criteria and priorities that are determined by owner requirements and preferences as well as the characteristics of the individual contractors.

MATERIALS AND METHODS

In this section, AHP methodology is given. And then, the contractor selection problem is structured.

Analytic Hierarchy Process

Analytic Hierarchy Process is one of the most widely used multiple criteria decision making tools [15]. Many outstanding works have been published based on AHP. They include applications of AHP in different fields such as planning, selecting best alternative, resource allocations, resolving conflict, optimization, etc., as well as numerical extensions of AHP [16].

The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency [17].

Table 1. Measurement Scales [18]

Intensity of Importance	*Verbal Judgment or Preference*
1	Equal Importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4,6 and 8	Intermediate values (when compromise is needed)

Analytic Hierarchy Process is an eigen value approach to the pairwise comparisons. It also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from1/9 for least valued than, to 1 for equal, and to 9 for absolutely more important than covering the entire spectrum of the comparison. The measurement scales of the method is shown in Table 1.

Some key and basic steps involved in this methodology are:

(1) State the problem,

(2) Broaden the objectives of the problem or consider, all actors, objectives and its outcome,

(3) Identify the criteria that influence the behavior,

(4) Structure the problem in a hierarchy of different levels constituting goal, criteria, subcriteria and alternatives,

(5) Compare each element in the corresponding level and calibrate them on the numerical scale. This requires n(n-1)/2 comparisons, where n is the number of elements with the considerations that diagonal elements are equal or 1 and the other elements will simply be the reciprocals of the earlier comparisons,

(6) Perform calculations to find the maximum Eigen value, consistency index CI, consistency ratio CR, and normalized values for each criteria/alternative.

(7) If the maximum Eigen value, CI, and CR aresatisfactory then decision is taken based on the normalized values; else the procedure is repeated till these values lie in a desired range[15].

However, perfect consistency rarely occurs in practice. In the AHP the pairwise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding consistency ratio (CR) is less than 10% [18].

The CR coefficient is calculated as follows. First the consistency index (CI) needs to be estimated. This is done by adding the columns in the judgment matrix and multiply the resulting vector by the vector of priorities (i.e., the approximated eigenvector) obtained earlier. This yields an approximation of the maximum eigen value, denoted by λ_{max}. Then, the CI value is calculated by using the formula: CI = $(\lambda_{max} - n)/(n - 1)$. Next the consistency ratio CR is obtained by dividing the CI value by the Random Consistency index (RCI) as given in Table 2. If the CR value is greater than 0.10, then it is a good idea to study the problem further and re-evaluate the pairwise comparisons[17].

Table 2. RCI values for different values of *n*

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Data Collection

Relational data were derived from questionnaire administered on experts which consist of 3 architects and 2 civil engineersto determine the order of importance of the contractor selection criteria. The pairwise comparison process elicits qualitative judgments that indicate the strength of the experts' preference in a specific comparison according to Saaty's 1-9 scale. Final weights are calculated by taking the arithmetic average of the weights obtained from pairwise comparisons of experts. Final weights were then used as input for the AHP and AHP steps are carried out by using Excel.

Analysis and Results

Contractor selection problem represents a typical MCDM problem that entails multiple criteria that can be both qualitative and quantitative. The hierarchy structure of contractor selection shown in Figure 1.

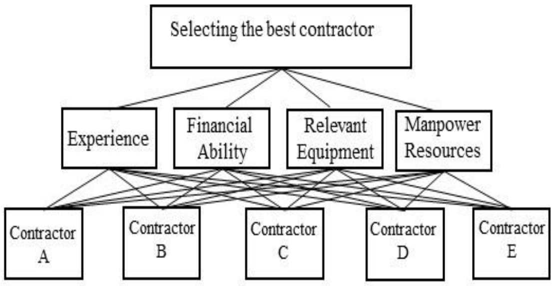

Figure 1 AHP Hierarchy of Contractor Selection Problem.

After constructing the hierarchy, pairwise comparisons are made. There are 5 pairwise comparison matrices in all: One for the criteria with respect to the goal, which is shown here in Table 3.

Then, there are 4 comparison matrices for the four alternatives with respect to all the criteria connected to the alternatives. These four matrices comparing the alternatives with respect to each criteria are shown in Tables 4. According to the results in Table 4, the best alternative is E respect to Experience and Financial ability criteria, alternative A is the best one respect to Relevant Equipment criteria and the best alternative respect to Manpower resources criteria is D.

Final results are given in Table 5. Therefore the best contractor is E (34.4%) followed by contactor A (22,8%). The following contractors are respectively D (19.6%), B (11.8%) and C (11.4%).

Table 3. Pairwise comparison matrix for the alternatives with respect to the Goal

Criteria	Experience	Financial A.	Relevant E.	Manpower R.	Priority
Experience	1	6	7	3	0.588
Financial A.	1/6	1	1	1	0.120
Relevant E.	1/7	1	1	1/5	0.076
Manpower R.	1/3	1	5	1	0.216
CR=0.088					

Table 4. Pairwise comparison matrix of the main criteria with respect to the Experience, Financial Ability, Relevant Equipment and Manpower Resources

Experience	A	B	C	D	E	Priority
A	1	3	4	5	1/3	0.287
B	1/3	1	1	3	1/4	0.120
C	1/4	1	1	1	1/3	0.096
D	1/5	1/3	1	1	1/3	0.076
E	3	4	3	3	1	0.423
CR= 0.082						

Financial A.	A	B	C	D	E	Priority
A	1	1	1/3	1/4	1/3	0.083
B	1	1	1	1/3	1/3	0.105
C	3	1	1	1/2	1/5	0.137
D	4	3	2	1	1	0.306
E	3	3	5	1	1	0.369
CR= 0.050						

Relevant E.	A	B	C	D	E	Priority
A	1	2	1	5	3	0.377
B	1/2	1	1	1	2	0.169
C	1	1	1	1	2	0.205
D	1/5	1	1	1	3	0.164
E	1/3	1/2	1/2	1/3	1	0.085
CR=0.067						

Manpower R.	A	B	C	D	E	Priority
A	1	1	1	1/7	1/2	0.093
B	1	1	1	1/3	1/3	0.104
C	1	1	1	1/2	1/2	0.125
D	7	3	2	1	4	0.474
E	2	3	2	1/4	1	0.203
CR= 0.061						

Table 5. Final Results

Alternatives	Criteria (CR: 0,088 < 0,10)				Overall Priority
	Experience (0,587685)	Financial A. (0,120382)	Relevant E. (0,076382)	Manpower R. (0,215551)	
A	0,287237	0,082938	0,376576	0,093256	0,228
B	0,119770	0,105350	0,169241	0,103971	0,118
C	0,093568	0,137431	0,204767	0,125378	0,114
D	0,076020	0,305614	0,164032	0,474386	0,196
E	0,423406	0,368666	0,085384	0,203009	0,344
CR	0,082<0,10	0,05<0,10	0,07<0,10	0,06<0,10	

CONCLUSION

The success level of any construction project heavily depends on contractor. Therefore, the selection of the most appropriate contractor for the project is an important issue. In this paper, we presented an AHP application for contractor selection in multicriteria environment. The AHP method allows to decision makers to express their opinions about the criteria. In our application five contarctors are compared according to criteria: experience, financial ability, relevant equipment and manpower resources. While the most important criteria is experience with importance weight 58.8% and the best contractor is E with importance weight 34.4%. In future works, the other multicriteria decision making methods and fuzzy multicriteria decision making techniques may apply the contractor selection problem.

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