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An AHP-Evaluation Models for Ranking Construction Tenders Using Simulation: A Case Study in Kurdistan Region of Iraq

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Abstract

In ranking decision alternatives, Analytic Hierarchy Process is regarded as one of the most successful techniques to deal with multiple criteria decision making problems. Recognizing that tender evaluation is a typical multi-criteria decision making problem, this paper introduces an evaluation approach based on AHP methodology for ranking various alternative options, each represents a construction project the tender, and then selecting the best one. The proposed model can guide decision makers in construction industry identify contractors with the best potential to deliver satisfactory outcomes in a final process of tender selection in Kurdistan Region of Iraq. Moreover, in order to reduce the inherent uncertainty within the AHP, which may significantly affect the decision process, a new methodology is proposed by using simulation. This model is tested by a hypothetical scenario where six tenders are evaluated and then, the best candidate is selected. Furthermore, the criteria used for the tender selection in the model and the significance of each criterion had been arrived at by conducting the first survey study for public and private organizations in Kurdistan Region of Iraq.

I. Introduction

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. There are various decision making approaches, among which AHP technique has been developed to become the most widely used method to deal with multi criteria decision making problems. Since AHP was introduced by Saaty (Saaty 1978, and 1980), it has been applied in various fields such as operations research, management science, financial economics, and many others with impressive results (Zahedi, 1986; Shim, 1989; Vargas, 1990; Wu, 2007; Fatah, 2009; Okoe et al., 2013 and Ramanathan, 2013); all these applications have shown the suitability of AHP in solving different types of multi-criteria decision-making problems.

In construction industry, to deliver a successful construction project, construction companies and other organizations are often confronted with the decision to select the most qualified tender (contractor) among the list of all options. In making unbiased decisions and transparent completion tendering, in addition to the tender price, various criteria such as skill and qualification of the contractor, past experience and past performance, financial capability and subjective judgments of the experienced construction experts, engineers within governmental ministries and universities or construction company owners (private clients, local and international), should be considered simultaneously. To employ selection methods that provide systematic methodology to incorporate the bid price with these decision criteria, AHP has been found as a useful and practical multi-criteria decision analysis tool (Odeyinka, 2006; Jiang et al., 2011).

Fatah (2009) studied the appropriators of the AHP approach to support tender selection process in KR. The study proposed a modified AHP model to rank pairs of alternative options; each represents a construction tender and, then select the most qualified one, which is with the highest weight. In order to identify the main criteria, which are believed to be the most important criteria for the selection process, a main survey was conducted. The obtained data from that survey was used to specify the main criteria and then assess their weights. The respondents to the main survey were 423 experienced or consultant engineers from various construction directorates and departments of related ministries in KR government and experienced lecturers working for different universities who are specialized in the field of construction industry in addition to contractors from various construction companies (local and international) working in KR.

Therefore, the proposed model helped in reducing the complication of using too many pair wise comparisons needed to apply the AHP model for comparing pairs of alternative options and then to determine the weights of such options (Saaty, 1990). Moreover, in order to overcome the main short coming of the AHP model, which is uncertainly, the modified model used an algorithm based on Box and Muller procedure, (Box and Muller, 1958), by using simulation.

In this paper, the main objectives are:

First: to extend the proposed AHP model (Fatah, 2009), which can only be used to rank pairs of alternative options , and introduce an AHP model that enables the ranking process to include more than two options and, then selects the most qualified one among all.

Second: to overcome the main short coming of the AHP model, which is uncertainly, this paper introduces a new approach. Using simulation, the new methodology proposes an algorithm which is more efficient in reducing uncertainty within the AHP model than what was proposed before by using Box and Muller approach (Box and Muller, 1958).

This model is tested by a hypothetical scenario where six contractor candidates are evaluated and then ranked, according to their weights; hence, the option with the highest weight is selected. The criteria used for contractor selection in this model and their significance are obtained from the first survey study conducted for public and private organizations in Kurdistan Region of Iraq (Fatah, 2009). Comparisons are made by ranking the aggregated scores of alternative options with regard to their performances against each of the criteria, and the one associated with the highest score is the best option to be selected. Later, some conclusions upon the appropriateness of the AHP to support TSP decision-making are presented. This paper is organized as follows: following an introduction in section 1, literature review on Kurdistan Region of Iraq and the process of tender selection are briefly presented in section 2. In section 3, the AHP methodology and the uncertainty within the AHP are introduced in addition to the selection of the main criteria with the assignment of their weights. Hence, the new evaluation approach and its methodology are explained in detail in section 4. In section 5, implementation of the proposed model and the simulation results are displayed. Finally, the summary and the main conclusion for this study are described in section 6.

II. Literature Review

A selected literature on Kurdistan Region of Iraq and the process of tender selection are briefly reviewed. Kurdistan Region (KR) is the only independent region in north of Iraq with a stable security situation. Since the last decade (after 2003), KR is experiencing an extreme economic growth incomparable to any other parts of Iraq. During this period, the region has seen fundamental changes in the economic structure, especially construction industry. As part of construction development plan for KR, many strategic construction projects have been undertaken where the successful execution of these projects are heavily impacted by making the right decision during tendering process.

Like many developing countries in the world, clients (construction companies for both public and private sector) in KR select tenders applied by contractors based on a set of criteria but decision relies heavily on the lowest price, which is considered as one of the main reasons for the failure of projects. Banaitiene and Banaitis (2006) provided sample attitudes cited by researchers since 1967 concerning the influence of the tender price on the final selection. It was found that the lowest price does not necessarily achieve the best selection and the lowest bidders have failed to complete projects. Moreover, despite the massive construction project achievements in the region, to evaluate tenders, there is no structured formalized procedure practiced that can guarantee the minimum standards for the quality of the selection process. However, some contractor selection methods are currently in use, they are criticized as incomplete, biased, and lacking consideration in terms of the contractor's ability to achieve simultaneously, time, cost, quality and safety standards. Another weakness in the current literature is that qualitative criteria are often not incorporated in most reported approaches, while in many real world applications; qualitative criteria are often the primary concerns for the evaluation process. Furthermore, due to the lack of the research studies that have been carried out on this process, there exists no published data that can be used as primary information for conducting structured methods to evaluate tenders; it depends, to a great extent, on the knowledge and skill of the clients. These extend the demand for more research in this field in addition to the need for developing standardized methods to assist in the evaluation process. Fatah (2009) introduced the first research survey to identify common criteria that are believed to have significant impact on the process of tender selection in KR, which has received a minimum consideration, with the evaluation of their weights by using expert's information. Furthermore, the study proposed an AHP based model to rank only pairs of alternative options representing construction tenders and then select the best contractor.

III. Analytic Hierarchy Process (AHP)

The AHP is considered as one of the most well-established and widely used methods for solving multi-criteria decision problems. It has the advantage of handling not only quantitative, but also intangible qualitative criteria and permitting a hierarchical structure of the criteria and alterative options and, then determines the relative importance for a given set of alternatives, based on the judgments of decision maker. The methodology of the AHP is based on a pair-wise comparison procedure, which compares criteria, or alternatives, with respect to a criterion to establish the preference matrices. Hence, the nine-point scale, Saaty scales from 1-9, is used; each number represents one's judgments to the decision process.

The basic procedure to carry out the AHP methodology consists of the following steps (Saaty, 1980);

1. Structure of the model to specify the overall objectives of the decision problem.
2. Comparative judgment of the alternatives and the criteria to determine the relative weights.
3. Synthesis of the priority vectors and the weights of the criteria by aggregating their total effect in regard with each single criterion. In this step, the procedure of normalization is necessary because the units of the criteria are always different. Finally, the option scores are combined with the criterion weights to produce an overall score for each alternative option.

The AHP was acknowledged by many researchers, in various fields, (Yanga and Shia, 2002; Li and Li, 2009 and Abednego et al., 2013) as an excellent tool and a flexible model that can assist decision makers in organizing their thoughts to make more effective decisions by personal judgments in a logical way. Moreover, the possibility of using this approach for evaluating and selecting projects was studied by many authors (Al-Harbi, 2001 and Hunag et al., 2008).

Despite that decision makers are rarely consistent in their judgments with respect to qualitative aspects; an AHP has the ability to deal with their personal inconsistencies. The method incorporates such inconsistencies into the model and provides the decision maker with a measure of these inconsistencies. A consistency ratio is taken as the ratio of the consistency of the results being tested to the consistency of the same problem evaluated with random numbers. This ratio provides the decision maker with a value that can be used to judge the relative quality of the results. If a consistency ratio of less than 0.1 is obtained, then the results are sufficiently accurate, and further evaluation is not needed . However, if the consistency ratio is greater than 0.1, then the results may be arbitrary and the preferences should be re-evaluated or discarded (Saaty, 1980 and 1994). While, the AHP allows for checking the consistency of an individual's judgments, the problem of uncertainty is considered as the main deficiency for the AHP.

1- Uncertainty in the AHP

The main purpose of using the AHP is to determine the relative ranking of various options where all alternatives are compared with respect to each criterion by using ratio scales. The accuracy of these comparisons significantly relies on information available to the decision makers. In most cases, the pair wise comparison involves a degree of uncertainty especially the judgmental uncertainty which may result from a number of factors such as the subjective state of the decision maker and insufficient source of information regarding all aspects of the decision problem. Thus, the AHP is widely used; the problem of uncertainty remains the main deficiency associated with this approach.

The judgmental uncertainty, which is one of the main weaknesses of the AHP methodology, is associated with the mapping of one's subjective judgment to a number. It was first defined by Saaty (1978), and, then later, it has been studied and investigated by many researchers for years. These studies mostly deal with uncertainty and its effect on the decision problems. This deficiency with the AHP often led the method to be criticized (Dyer, 1990; Belton and Gear, 1993; Fatah, 2009 and Lin and Wing, 2012). Therefore, to propose the AHP-based models to solve decision problems, the inherent uncertainty should be studied first. For this purpose, various methods and simulation based approaches has been introduced, they can deal with uncertainty and then analyze its effect on the decision process (Paulson and Zahir, 1995; Hauser and Tadikamalla, 1996; Wu, 2007; Lin et al., 2008). The methodology introduced by Fatah (2009) ensures limiting the inherent uncertainty with the proposed AHP model, which is resulted from the judgmental diversities for the experts in the preference matrix and represented by the variance σ^2, to an accepted level specified by the decision maker. With this procedure, using Box-Muller formula (Box and Muller, 1958), to generate a single random variable from the standard normal distribution by using simulation, at least, two independent random numbers form the same uniform density function on the interval (0,1) are required in addition to the undesired computations of the sine and cosine functions, which is time consuming.

In this study, to reduce the uncertainty within the AHP to an accepted level for the proposed model, a new approximation method is introduced by using simulation. First, to generate different standard normal variables, a new approximation technique is presented by using the new approach proposed by Rao et al. (2011). This new procedure uses the logistic approximation of the cumulative normal distribution (Bowling et al., 2009); where the best logistic fit for the cumulative function of standard normal distribution is given by:

$$g(z) = 1/(1+e^{-1.702z}) \quad (1)$$

This approximation function can be used to generate different random numbers from the standard normal distribution by using the inverse transform method and, then each standard normal variable will be defined by using only one uniform random variable and in only two steps. First, it generates a uniform random variable U from U(0,1) distribution. Second, it defines a new normal random variable as $X = (-\mathrm{Ln}(1/u - 1))/1.702$. This approximation technique avoids the computations of the sine and cosine functions as it is required for Box and Muller method (Box and Muller, 1958).

The following algorithm describes the new approach for reducing the judgmental uncertainty within the AHP to a specified level denoted by δ; this level is assumed to be the boundary for the uncertainty within the same matrix. The matrix uncertainty represents the consensus of variances within that matrix; it is identified by the decision maker at the beginning of the process of applying the AHP.

Algorithm 1

This algorithm introduces a new technique to reduce the uncertainty within the AHP, to some level, for each preference judgmental matrix. Using simulation, it generates different normal random preference matrices. For each, the Eigen-Vector and its associated variance and then its standard deviations are determined. Hence, a matrix can be identified and accepted as the desired preference matrix, with a standard deviation of its associated Eigen-Vector does not exceed the boundary level δ, that satisfies the condition of having uncertainty bounded to the required level δ. Otherwise, the procedure of the algorithm will be repeated until the required matrix, which will possess a specified level of uncertainty, is obtained.

This algorithm is explained in the following steps:

1. Generate a reciprocal matrix A from the judgments of decision makers, $A = a_{ij}$ where a_{ij} is a uniform random values lies between 1-9 and the reciprocal a_{ji} is set equal to $1/a_{ij}$, for $i \neq j$ and $a_{ij} = 1 \;\; for\; i = j$.
2. Generate a set of N random matrices $[A^1, A^2, ..., A^N]$, assuming that elements of each A^K is normally distributed random variables with sample mean equal $\overline{X}_K$ and Sample variance is S_K^2. For each A^K, elements $a_{ij}{}^K$ are generated as:
   I. If $a_{ij} \geq 1$, then $a_{ij}^k = -[ln(1/(u-1)] / 1.072 * S_k + a_{ij}$, where $u \sim u(0,1)$, random number is generated from the uniform distribution function;
   II. Else $a_{ij}^K = 1/a_{ij}$, for all $i, j = 1,2,..., n, k = 1, N$.
3. Calculate W^K, the principal Eigen-Vector for the reciprocal matrix for each A^K.
4. Calculate the mean w_K and the standard deviation S_K for each principal Eigen-Vector W^K.
5. If $S_K \leq$ δ (the limit value for uncertainty) accepts the random matrix as the preference matrix, otherwise step 2 is repeated.

In this algorithm, step 1 generates the reciprocal matrix A, where a_{ij}, elements of A, are obtained from the decision maker's opinion mapped into Saaty's nine-point scale, 1-9, and when $i = j$, which means that the preference, or the importance of one criterion, or alternative to itself is the same, then $a_{ij} = 1$. When $i > j$, then the reciprocal elements a_{ji} are defined, $a_{ji} = 1/a_{ij}$.

In step 2, N random matrices $[A^1, A^2, ..., A^N]$ are generated and elements a_{ij}^k, for each matrix A^K using the new approximation approach. Then, for each of the generated normal reciprocal random matrix A^K the principle Eigen-Vector is determined, from the principle of linear algebra, the Eigen-Value technique in step 3 and the variance, for each of Eigen-vectors, are determined from Step 4. Finally, the determined standard deviation is compared with δ, if the standard deviation of the Eigen-vector for a generated matrix does not exceed this boundary then this matrix can be accepted as a preference matrix, which would be used for processing the AHP technique, otherwise the whole procedure will start again from step 2 until the required preference matrix is found.

2- Selection of Criteria and Assignment of Weights

To apply the AHP methodology, one of the basic steps is the selection of the main criteria with assignment of their weights, which is a challenging process as different experts have different perception on the importance of each of the criteria used, depending on the relevance of the criteria to their specific area of concern. Data analysis for the survey conducted by Fatah (2009), identified the main criteria and their importance (ranking) by using the method of rank sum weighting which maps the ranks linearly (i.e. with equal distances) on the interval [0:1] (Schutz, et al, 2006), and the weight for each criterion is then assessed using the following formula:

$$W_i = (n - r_i + 1) / \sum_{k=1}^{n} (n - r_k + 1) \qquad (2)$$

Where n is the total number of criteria, $r_i,\ i = 1, \cdots, n$ is the rank order for each criteria. The following table, presents the main criteria with their assessed weights.

Table. I: Main criteria and their assessed weights

	Main Criteria	*Weight*
1	*Past experience*	*0.1587*
2	*Past performance*	*0.1415*
3	*Tender's qualification and skill*	*0.1354*
4	*Financial capability*	*0.1112*
5	*Governmental support*	*0.1031*
6	*Material price stability*	*0.0909*
7	*Resources (human and technical)*	*0.0748*
8	*Currency stability*	*0.0606*
9	*Lowest tender price*	*0.0415*
10	*Current work load*	*0.0303*
11	*Other*	*0.052*
Total weight		*1*

However, in applying the AHP approach, the less important elements can be dropped from further consideration because of their relatively small impact on the overall objective; the priorities can then be recomputed throughout, either with or without changing the judgments (Saaty, 1990). In this study, the total number of criteria is reduced to seven main criteria and their weights are re-calculated by using the same procedure. Table.II displays the list of the main criteria used in this study with their assessed weights (rounded to three decimals).

Table.II: The Most Important Criteria and their Weights

	Main Criteria	*weight*
1	*Past experience & Past performance*	*0.377*
2	*Tender's qualification and skill*	*0.170*
3	*Financial capability*	*0.140*
4	*Governmental support*	*0.129*
5	*Resources (human and technical)*	*0.094*
6	*Lowest tender price*	*0.052*
7	*Current work load*	*0.038*
Total weight		*1*

IV. The New Evaluation Approach and the Methodology

The main objective of this study is to introduce a new evaluation approach based on the AHP, which is with a limited uncertainty that can be used as a systematic procedure for ranking various alternatives options in construction industry. In this section, an overview and the methodology for the new proposed model are explained, using simulation. The main goal and levels for the hierarchy are presented and, then the significant components, criteria and alternatives, are identified and the role played by each one, is explained. For this model, various simulated random variables are considered where the ranking procedure will be according to the described methodology. Hence, the proposed model is applied to a case study concerning an important process for financial investment, which is the TSP for construction projects in KR of Iraq.

Therefore, the startup step should identify the problem and the main goal. Here, the problem is ranking alternative options based on different factors and the main goal is defined to be the selection of the best option, taking into account all quantitative criteria in addition to the subjective judgments of all experts who take part in the decision process. Hence, the next step, following this definition, involves the construction of the hierarchy structure; three main levels are identified. The first level is the main goal; the second is the level of criteria. For the hierarchy of the proposed model, only seven important criteria, in the second level, are considered and the number of alternatives is assumed to be six options in the third level. The following figure, describes the levels for the hierarchy of this model.

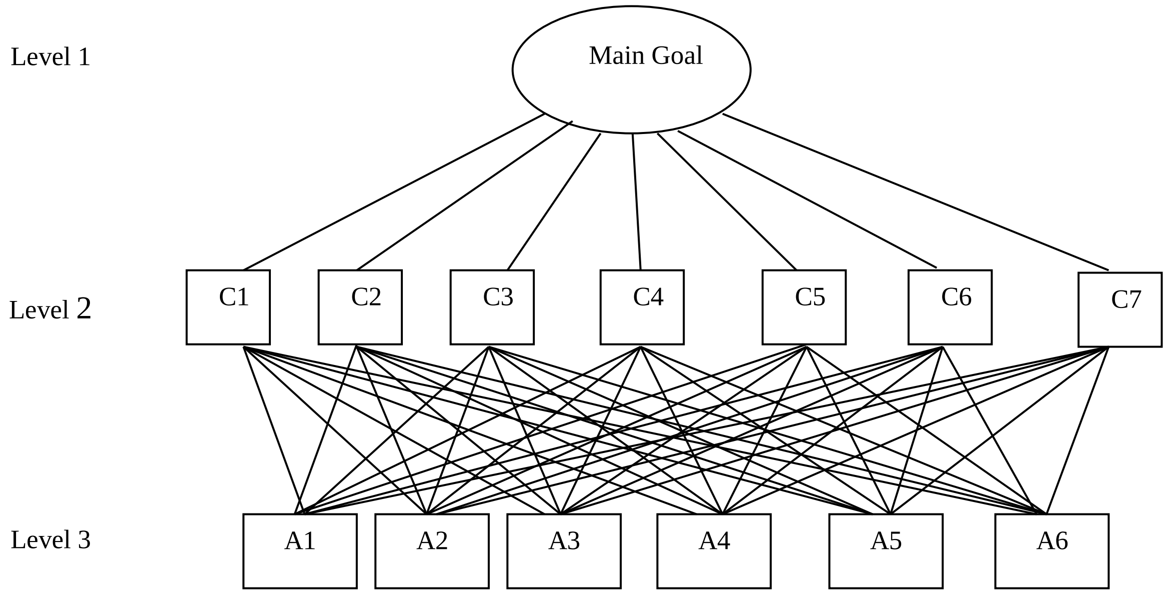

Fig.1: AHP for the Proposed Model

Hence, preference matrices, each represents the expert's preference judgments for the alternative options, in the lower level, associated with a criterion identified in the level above, are constructed by using relative scale measurements (1-9). At this stage, to set up matrices, a team of experts is required. For this application, due to the lack of experienced people in the field of this study in KR, preference matrices are generated by using simulation. In order to specify preference matrices, each with a limited uncertainty identified by the decision maker. Algorithm 1, which is described earlier, is applied to each comparison matrix; the process is started at the bottom level and move upward. Then, based on the AHP axioms, ratio scales are derived and priorities are synthesized from the second level down by multiplying local priorities by the priority of their corresponding criterion in the level above, and adding them for each element in a level according to the criteria it affects. Finally, an overall weight scale is determined for each option; it is used as the basis for ranking all alternative options.
The following algorithm describes the new proposed model framework and explains its methodology.

Algorithm 2

Step 1: Define the decision problem and the main goal;
Step 2: Structure the hierarchy from the top through the intermediate to the lowest level;

Step 3: Construct comparison matrices for alternative options with respect to each criterion using steps, Step 3.1 to 3.4, below;

Step 3.1: Generate a preference matrix to represent the subjective judgments for the intensity of importance of one option over the other, using a nine-point scale. If the two are of equal importance, then a value of 1 is given in the comparison matrix while a 9 refers to an absolute importance.

Step 3.2: Generate, for each constructed matrix, a reciprocal normal random matrix to represent such matrix, using Algorithm 1. This new reciprocal matrix is with a specified level of uncertainty δ; the value of δ is identified, by the decision maker, at the beginning of the process;

Step 3.3: Estimate the relative weights, importance, for each decision factor by using the Eigen- value method; the principle Eigen-vector correspond to the largest Eigen-value of each matrix constitutes the estimation of relative weights, local priorities. A computer program is used to calculate the Eigen-vectors and Eigen values, by using MATLAB.

Step 3.4: Calculate the consistency for the preference matrix; a matrix is consistent if the numbers of the factors include in the decision process is approximately equal to the maximum Eigen-value; i.e., $\lambda_{\max} = n$, n is the number of criteria for each level . A consistency index CI , measures the inconsistencies of pair wise comparisons, is given by:

$CI = (\lambda_{\max} - n)/(n-1)$, where n is the number of criteria for each level.

Then, the consistency of the comparison matrix CR is:

$CR = CI/RI$, RI is the random index; its value depends on the order of the preference matrix.

Step 4: Perform steps 3.1-3.4 for all levels in the hierarchy;

Step 5: Aggregate relative weights of various levels, obtained from step 3.3, to obtain the ranking scale for the decision alternatives.

Algorithm 2 explains that when the decision problem and the main goal are identified, then the hierarchy for this problem is constructed. Using simulation, seven preference matrices, each represents the selected matrix for the preference of one option to the other with respect to one criterion, are generated by using nine-point scales. Using Algorithm 1, a random normal reciprocal matrix with a specified level of uncertainty is generated for each of such generated matrices to determine an Eigen Vector and, then the relative weight is estimated using Eigen-Value method. Hence, the relative weights for all options are aggregated with the estimated weights for the main seven criteria (Table.II) to obtain the final weight for each of such options. Finally, when the ranking scales for the decision alternatives are identified then the option with the highest weight is selected.

V. Implementation of the Model and Simulation Results

In this section, the proposed framework for the new approximation model is used as a new strategy to solve a real-life problem in a field of financial investments in construction industry. It is theTSP, which has significant impact on the success of implementing construction projects in Kurdistan Region of Iraq. It is assumed that a scenario where six alternatives, each represents a construction tender, is considered. The aim is to select the most qualified tender or contractor based not only on the lowest price, but also on other important criteria, which are identified by experts in KR. Moreover, to apply the proposed model to the case study, preference matrices, each matrix represents expert’s judgments, are simulated. The implementation of the new model, which is applied to a hypothetical scenario where six options are considered, and the simulation results are explained by the following tables.

The matrix in Table.III represents the preference judgments for six construction tender options (A1-A6) with respect to the first criterion (C1), past experience and past performance. The preference matrix is normalized and then converted into a matrix with a limited uncertainty by using simulation where different iteration are performed until the required conditions are obtained as described in algorithm 1. Hence, the

Eigen Vector represented by P. Weight is determined. Each value of P. Weight represents a weight scale for an alternative option. For example, 0.2229 is the weight for the first option A1 with respect to criterion C1 and 0.0995 is the weight for the second option A2 with respect to the same criterion C1and so on.

Table.III: Weights for Options with Respect to the Criterion C1

C1	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*0.1111*	*1.0000*	*0.1429*	*3.0000*	*1.0000*	*0.2229*
A2	*9.0000*	*1.0000*	*0.3333*	*9.0000*	*3.0000*	*0.2000*	*0.0995*
A3	*1.0000*	*3.0000*	*1.0000*	*9.0000*	*0.2000*	*5.0000*	*0.1460*
A4	*7.0000*	*0.1111*	*0.1111*	*1.0000*	*3.0000*	*0.1429*	*0.2468*
A5	*0.3333*	*0.3333*	*5.0000*	*0.3333*	*1.0000*	*1.0000*	*0.1799*
A6	*1.0000*	*5.0000*	*0.2000*	*7.0000*	*1.0000*	*1.0000*	*0.1049*

Similarly, as in Table. III, Table. IV displays the steps for determining the weights for all options (A1-A6) with respect to the second criterion C2.

Table.IV: Weights for Options with Respect to the Criterion C2

C2	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*0.1429*	*1.0000*	*1.0000*	*5.0000*	*1.0000*	*0.1088*
A2	*7.0000*	*1.0000*	*0.1111*	*3.0000*	*5.0000*	*0.1429*	*0.2040*
A3	*1.0000*	*9.0000*	*1.0000*	*5.0000*	*3.0000*	*0.1111*	*0.1991*
A4	*1.0000*	*0.3333*	*0.2000*	*1.0000*	*0.1429*	*9.0000*	*0.1142*
A5	*0.2000*	*0.2000*	*0.3333*	*7.0000*	*1.0000*	*7.0000*	*0.1538*
A6	*1.0000*	*7.0000*	*9.0000*	*0.1111*	*0.1429*	*1.0000*	*0.2202*

Tables V - IX are similar preference matrices with respect to other criteria, criterion C3- C7.

Table.V: Weights for Options with Respect to the Criterion C3

C3	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*1.0000*	*1.0000*	*0.3333*	*5.0000*	*5.0000*	*0.1827*
A2	*1.0000*	*1.0000*	*1.0000*	*9.0000*	*0.1429*	*0.1429*	*0.1208*
A3	*1.0000*	*1.0000*	*1.0000*	*9.0000*	*5.0000*	*0.1429*	*0.1852*
A4	*3.0000*	*0.1111*	*0.1111*	*1.0000*	*1.0000*	*0.3333*	*0.1052*
A5	*0.2000*	*7.0000*	*0.2000*	*1.0000*	*1.0000*	*7.0000*	*0.1834*
A6	*0.2000*	*7.0000*	*7.0000*	*3.0000*	*0.1429*	*1.0000*	*0.2225*

Table.VI: Weights for Options with Respect to the Criterion C4

C4	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*9.0000*	*3.0000*	*0.1429*	*7.0000*	*5.0000*	*0.3085*
A2	*0.1111*	*1.0000*	*1.0000*	*3.0000*	*7.0000*	*9.0000*	*0.1776*
A3	*0.3333*	*1.0000*	*1.0000*	*9.0000*	*1.0000*	*7.0000*	*0.1986*
A4	*7.0000*	*0.3333*	*0.1111*	*1.0000*	*5.0000*	*7.0000*	*0.2246*
A5	*0.1429*	*0.1429*	*1.0000*	*0.2000*	*1.0000*	*7.0000*	*0.0741*
A6	*0.2000*	*0.1111*	*0.1429*	*0.1429*	*0.1429*	*1.0000*	*0.0166*

Table. VII: Weights for Options with Respect to the Criterion C5

C5	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*9.0000*	*3.0000*	*0.1429*	*9.0000*	*0.2000*	*0.2186*
A2	*0.1111*	*1.0000*	*1.0000*	*1.0000*	*5.0000*	*9.0000*	*0.1960*
A3	*0.3333*	*1.0000*	*1.0000*	*0.1111*	*9.0000*	*1.0000*	*0.0919*
A4	*7.0000*	*1.0000*	*9.0000*	*1.0000*	*1.0000*	*0.1111*	*0.2185*
A5	*0.1111*	*0.2000*	*0.1111*	*1.0000*	*1.0000*	*0.1429*	*0.0264*
A6	*5.0000*	*0.1111*	*1.0000*	*9.0000*	*7.0000*	*1.0000*	*0.2486*

Table. VIII: Weights for options with respect to the criterion C6

C6	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*7.0000*	*0.3333*	*0.1429*	*0.1111*	*1.0000*	*0.1431*
A2	*0.1429*	*1.0000*	*3.0000*	*1.0000*	*7.0000*	*1.0000*	*0.2365*
A3	*3.0000*	*0.3333*	*1.0000*	*0.3333*	*1.0000*	*7.0000*	*0.1410*
A4	*7.0000*	*1.0000*	*3.0000*	*1.0000*	*1.0000*	*1.0000*	*0.1920*
A5	*9.0000*	*0.1429*	*1.0000*	*1.0000*	*1.0000*	*7.0000*	*0.2112*
A6	*1.0000*	*1.0000*	*0.1429*	*1.0000*	*0.1429*	*1.0000*	*0.0762*

Table. IX: Weights for Options with Respect to the Criterion C7

C7	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*P.Weight*
A1	*1.0000*	*7.0000*	*5.0000*	*1.0000*	*1.0000*	*9.0000*	*0.3080*
A2	*0.1429*	*1.0000*	*7.0000*	*7.0000*	*0.3333*	*1.0000*	*0.1712*
A3	*0.2000*	*0.1429*	*1.0000*	*0.3333*	*9.0000*	*0.2000*	*0.1151*
A4	*1.0000*	*0.1429*	*3.0000*	*1.0000*	*5.0000*	*0.2000*	*0.1384*
A5	*1.0000*	*3.0000*	*0.1111*	*0.2000*	*1.0000*	*3.0000*	*0.1363*
A6	*0.1111*	*1.0000*	*5.0000*	*5.0000*	*0.3333*	*1.0000*	*0.1309*

Finally, the last table, Table X, determines the final aggregated weights for all options using the scale weights for all criteria C1-C7.

Table.X: Aggregated weights for all options(A1-A6)

W_1	W_2	W_3	W_4	W_5	W_6	***Total***
0.20038	*0.15954*	*0.16464*	*0.17912*	*0.14406*	*0.15225*	*0.99998*

In Table. X, W1 is the final scale weight (aggregated weight) for the first alternative option A1, W2 is the weight for the second option and so on. Hence, based on calculated weights, the first option is found to be with the highest weight; it is the best option to be selected.

VI. Summary

In this paper a new evaluation approach, which is based on the analytical framework of AHP, is proposed; it is an approximation framework that can be used as a structured procedure for ranking various alternative options, each represents a construction tender, and then selecting the best option. Meantime, in order to control the weakness of AHP results from the difficulty of setting up the right preference matrix to represent decision maker’s judgments, the study implements a new procedure described by an algorithm, Algorithm 1. The procedure for this algorithm restricts the uncertainty, which is considered as the average of the resulted variances associated with mapping the judgments to exact numbers, to a specific value. Then, to test the applicability of the designed algorithm to real life problems, a case study is considered; the obtained results indicated the power and the flexibility of the algorithm. The main contribution of this approximation approach is in controlling the limit of uncertainty within each preference matrix using a new procedure that can reduce the required number of generated random variables in addition to less computation using simulation. It provides a more accurate weight indicator that allows ranking preferences efficiently.

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