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UTA Method for the Consulting Firm Selection Problem

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Abstract

The market conditions change due to the introduction of new products, unforseen demand fluctuations, rapid change of the life cycle of products and profit margins. Therefore, companies try to survive in a competitive environment by making their operational decisions strategically and systematically. Selection problems play an important role among these decisions. In the literature there are many robust MCDM (Multi Criteria Decision Making) methods that consider the conflicting selection criteria and alternatives. In this paper the consulting firm selection problem is solved with UTA (UTility Additive) method which is one of the MCDM methods. This method considers preference of the decision makers on alternatives and uses linear programming model to obtain a utility function having a minimum deviation from the preferences. In order to illustrate the efficiency and effectiveness of the method, a real case study is presented.

Keywords: Multi Criteria Decision Making (MCDM), UTility Additive (UTA) method, consulting firm selection problem

1. Introduction

Today companies are utilizing every opportunity to cope with the changes in the market and to focus on the quality in both their products as well as their services. In this context, quality assurance system is the one of the parts of quality management in the companies. A quality assurance system includes analysis, standardization and documentation of each and every recurrent process in the life cycle of a product from design and manufacturing to packaging and distribution, controlling all their distinct stages [1]. Designing and constructing a quality assurance system prevent poor quality products from being shipped to customers and provide a systematic way for controlling damage and dealing with customer complaints [2]. Many organizations still do not know how to handle their quality efforts and implement a quality assurance system. In this situation consultants are hired from the external consulting firms which consist of consultants who are experts in their field and provides professional advice to an organization for a fee [3].

Once a company has decided to hire a consulting firm and determined specific needs and goals of the organization, next decision is to evaluate and select a suitable consulting firm which is a strategic problem for the management in terms of improving their organizational effectiveness. This problem is affected by many conflicting factors such as company's desired purposes, the limited resources and the company's preferences [4]. So this problem must be solved by using different methods which can incorporate the conflicting criteria and helps the organization for identifying the best alternative. In the literature, there are many studies which handle consulting firm selection with MCDM (Multi Critieria Decison Making) methods. Cheung, Kuen and Skitmore [5] applied AHP (Analytic Hierarchy Process) on the selection of architectural consultants. Cebeci and Ruan [6] presented the fuzzy AHP to compare Turkish quality consulting firms. Cebeci [7] provided an analytical tool based on fuzzy AHP to select the best JCI (Joint Commission International) consulting firms. Saremi, Mousavi and Sanayei [4] proposed a systematic decision process for selecting external consultant based on NGT (Nominal Group Technique) and fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). NGT was used for selecting the criteria and fuzzy TOPSIS was used to rank the consulting firms of Iranian auto part manufacturer. Omar, Trigunarsyah and Wong [8] presented the aspect of design, development and evaluation of decision support system based on DSRM (Design Science Research Method) and hierarchical fuzzy TOPSIS method for consultant selection in Malaysia. Tsai, Shen, Lee and Kuo [9] applied ANOVA (ANalysis of VAriance) and regression analysis to examine the impact of ERP (Enterprise Resource Planning) consultant selection factors on ERP project management and the impact of the ERP project management in the IS (Information System) success model. They used DeLone and McLean's IS success measurement category to develop ERP performance. Alencar and Almeida [10] presented consultants selection for a construction project based on PROMETHEE VI (Preference Ranking Organization Method for Enrichment Evaluations). Chu [11] evaluated and selected consulting firms by a centroid ranking approach based fuzzy MCDM method. The Euclidean distance based on centroid points was applied while defuzzing the evaluations to reach the ranking order of alternatives. Vayvay and Cruz [12] applied PRP (Project Resource Planning), AHP, fuzzy AHP and ANP (Analytic Network Process) methods for selection of ERP consultant alternatives. In their problem cost, work experience,

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education level and communication ability were considered as main criteria for comparing three consultant alternatives. As a result of their study both AHP and fuzzy AHP led to the same results but they couldn't consider the interactions within decision elements during the selection process. However ANP gave most correctly weights the sub-criteria and the best composite weights by taking into account these interactions. El-Santawy and Ahmed [13] proposed VIKOR (VIšekriterijumsko KOmpromisno Rangiranje) method to select the consulting firm for a multinational manufacturing company. They considered the company size, potential profit, expected growth and the cost as the criteria for evaluating consulting firm alternatives. El-Santawy and El-Dean [14] used MOORA (Multi Objective Optimization on the basis Ratio Analysis) method for ranking the firms. Assigning weights for criteria in the problem was employed with the SDV (Standard Deviation) and the method was called SDV-MOORA. Kabir [15] presented consultant selection for automotive battery manufacturing company based on VIKOR method with fuzzy set theory. Kabir and Sumi [16] formulated a consultant selection decision support tool based on fuzzy AHP and PROMETHEE for the furniture company.

Differently from the MCDM methods in the literature, this paper presents UTA (UTility Additive) method for the the selection of an appropriate consulting firm for its specific needs or business objectives. UTA method considers preference of the decision makers on alternatives and uses linear programming model to obtain a utility function having a minimum deviation from the preferences. In order to illustrate the efficiency and effectiveness of the method, a real case study is presented.

The rest of the paper is organized as follows. In Section 2 the methodological background of UTA method is illustrated. Section 3 is provided for the consulting firm selection problem. UTA method is applied to rank consulting firms for the textile company in Denizli, Turkey. Lastly in Section 4 the results of the application are presented and recommendations for future studies are discussed.

2. The UTA Method

The UTA (UTility Additive) method is the one of the MCDM methods and initially proposed by Jacquet-Lagreze and Siskos [17]. As the other MCDM methods, the main problem that must be solved in UTA method is to compare, rank and evaluate the set of alternatives considering different criteria which measure the favourable consequences of the alternatives. This method constructs decision models from a priori known decision or preference data in the form of ranked lists of alternatives [18]. It estimates a nonlinear additive function obtained by the use of a linear programming which provides a convenient piecewise linear approximation of the function. While estimating nonlinear additive function, it uses decision maker's global preferences between alternatives [19].

In the literature UTA method was applied to different selection problems such as contractor selection [20], an appropriate wastewater planning management system selection [21], road investment project selection in Belgium [19], staff evaluation [22], the evaluation of residential real estate [23], facility location selection [24], material selection [25], the evaluation of the MTS (Mass Transit Systems) development scenarios, ranking of the maintenance work contractors for the MTS renovation project and selection of the transportation mode for the MTS [26], material handling equipment selection by using WUTA (Weighted UTility Additive Theory) [27]. There are several variants of the UTA method applied in many decision making problems such as sales strategy [28], portfolio selection and management [29], business failure prediction [30], environmental management [31], marketing of agricultural products [32], customer satisfaction [33], strategic performance measurement in a healthcare organization [34].

While applying the UTA method, firstly the decision maker considers given ranking on a reference set of alternatives, $A_R = \{a_1, a_2 ..., a_m\}$, which is evaluated by a set of criteria, $g = (g_1, g_2, ..., g_n)$. g_i presents the performance of criterion *i*. If $g(a) = [g_1(a), g_2(a), ..., g_n(a)]$ is the multi criteria evaluation of an alternative *a*, then the following properties generally hold for the utility function, U(g).

$$U[g(a)] > U[g(b)] \Leftrightarrow aPb \tag{1}$$

$$U[g(a)] = U[g(b)] \Leftrightarrow aIb \tag{2}$$

In these situations *P* and *I* show strict preference and indifference relations respectively. The relation $R = P \cup I$ is a weak order. UTA method formulates an unweighted form of the additive value of function as:

$$u(g) = \sum_{i=1}^{n} u_i(g_i) \tag{3}$$

where $u_i(g_i)$ (i=1,2,…,n) is marginal value or utility function of the criterion g_i for the given alternative. These functions are non-decreasing real valued functions and normalized between 0 and 1. This formula is subject to normalization constraints as:

$$\sum_{i=1}^{n} u_i(g_i^*) = 1$$

$$u_i(g_{i*}) = 0 \qquad \forall i = 1,2,...,n \tag{4}$$

where g_i^* and g_{i*} are the best and the worst evaluation value of *i*th criterion respectively. Considering the additive model and the preference conditions utility of each alternative may be expressesed as:

$$u'[g(a)] = \sum_{i=1}^{n} u_i[g_i(a)] + \sigma(a) \qquad \forall a \in A_R \quad A_R = \{a_1, a_2 ..., a_m\} \tag{5}$$

$\sigma(a)$ is a non-negative potential error relative to the utility of each alternative *a*. The marginal value functions is assumed to have a piecewise linear form. The range of values of each criterion $[g_{i*}, g_i^*]$ is splited into $(\alpha_i - 1)$ equal segments. The end points, g_i^j, are calculated by the following formula:

$$g_i^j = g_{i*} + \frac{j-1}{\alpha_i - 1}(g_i^* - g_{i*}) \quad \text{for all } j = 1,2,...,\alpha_i \tag{6}$$

The marginal utility of an alternative is found by a linear interpolation method:

$$u_i[g_i(a)] = u_i(g_i^j) + \frac{g_i(a) - g_i^j}{g_i^{j+1} - g_i^j}\left[u_i(g_i^{j+1}) - u_i(g_i^j)\right]$$
$$\text{for } g_i(a) \in \left[g_i^j, g_i^{j+1}\right] \quad (7)$$

The optimal solution of the following linear programming model gives the marginal value functions:

$$\min F = \sum_{a \in A_R} \sigma(a)$$

subject to

$$\sum\{u_i[g_i(a)] - u_i[g_i(b)]\} + \sigma(a) - \sigma(b) \geq \delta \quad \text{if } a\,P\,b$$

$$\sum\{u_i[g_i(a)] - u_i[g_i(b)]\} + \sigma(a) - \sigma(b) = 0 \quad \text{if } a\,I\,b$$

$$u_i(g_i^{j+1}) - u_i(g_i^j) \geq 0 \quad \text{for all } i \text{ and } j$$

$$\sum_{i=1}^{n} u_i(g_i^*) = 1$$

$$u_i(g_{i*}) = 0 \quad \text{for all } i$$

$$u_i(g_i^j) \geq 0,\ \sigma(a) \geq 0 \quad \text{for all } i \text{ and } j \quad (8)$$

The objective function of this linear programming model is to minimize the sum of the errors. First and second constraints satisfy the decision makers's preference and indifference respectively. δ is a small positive number to discriminate significantly two successive equivalence classes of preference relation. The third constraint shows that partial utilities increased with the value of the criteria. The fourth and fifth constraints satisfy normalization. Finally last constraints are non-negativity conditions. The utility value $U[g(a)]$ for each alternative is calculated after computing the marginal utility values. Finally the alternatives are ranked in increasing order of utility values of the alternatives. Obtaining the ranking of the alternatives terminates the UTA method [17, 25, 35].

3. Application

In this part, the UTA method is applied to a textile company in Denizli, Turkey for the selection of an appropriate consulting firm. This company wants to make its employees get quality assurance system education to improve organizational effectiveness. The category of the education is Quality Management System (ISO 9001). The consulting firm selection process is a difficult task because of handling quantitative and qualitative criteria simultaneously. So the committee consisting quality managers of the company is assigned for this task. The committee firstly identify the five criteria to be compared for the consulting firm selection as follows: consultants, C_1 (the number consultants employed in the consulting firm), work experience, C_2 (number of years' experience in their field), technical skills, C_3 (the number of certificates of the consulting firm), references, C_4 (the number of references for consulting firm) and cost, C_5 (cost of the consulting firm to the textile company in TRY). Among these five criteria, the first four criteria are benefit criteria and the last one is cost criterion. Then committee determines ten consulting firms as alternatives (A_1, ..., A_{10}) and collects the data of each alternative under these five criteria as shown in Table 1.

Table 1. Data of the problem

	C_1	C_2	C_3	C_4	C_5
A_1	5	4	16	50	2000
A_2	2	6	36	70	900
A_3	3	6	32	12	1200
A_4	8	12	31	650	2000
A_5	4	15	42	425	700
A_6	30	11	28	430	2100
A_7	21	5	12	152	2100
A_8	24	10	28	850	900
A_9	11	13	16	830	700
A_{10}	5	10	11	170	900

Before applying the steps of UTA method, linear normalization of data for consulting firm alternatives on the five criteria is performed. The benefit and cost criteria are normalized separately and normalized decision matrix is shown in Table 2. Each element in this matrix shows the performance of *i*th alternative with respect to *j*th criterion. By taking the row sums of the normalized decision matrix reference ranking of the alternatives is obtained as A_8–A_5–A_9–A_6–A_4–A_2–A_{10}–A_3–A_7–A_1.

Table 2. Normalized decision matrix

	C_1	C_2	C_3	C_4	C_5
A_1	0,1667	0,2667	0,3810	0,0588	0,3500
A_2	0,0667	0,4000	0,8571	0,0824	0,7778
A_3	0,1000	0,4000	0,7619	0,0141	0,5833
A_4	0,2667	0,8000	0,7381	0,7647	0,3500
A_5	0,1333	1,0000	1,0000	0,5000	1,0000
A_6	1,0000	0,7333	0,6667	0,5059	0,3333
A_7	0,7000	0,3333	0,2857	0,1788	0,3333
A_8	0,8000	0,6667	0,6667	1,0000	0,7778
A_9	0,3667	0,8667	0,3810	0,9765	1,0000
A_{10}	0,1667	0,6667	0,2619	0,2000	0,7778

After determing the minimum (g_{i*}) and maximum (g_i^*) value of the each criterion and the number of intervals, interval difference for each criterion is computed using Eq. (6) and shown in the last column of the Table 3.

Table 3. Data used for ranking analysis

	g_{i*}	g_i^*	**Number of intervals**	**Interval difference**
C_1	0,0667	1	4	0,2333
C_2	0,2667	1	3	0,2444
C_3	0,2619	1	3	0,2460
C_4	0,0141	1	4	0,2464
C_5	0,3333	1	3	0,2222

By considering Table 2, the utility values for the alternatives are written as:

$U[g(A_1)] = u_1(0,1667) + u_2(0,2667) + u_3(0,3810) + u_4(0,0588) + u_5(0,3500)$

$U[g(A_2)] = u_1(0{,}0667) + u_2(0{,}4000) + u_3(0{,}8571) + u_4(0{,}0824) + u_5(0{,}7778)$

$U[g(A_3)] = u_1(0{,}1000) + u_2(0{,}4000) + u_3(0{,}7619) + u_4(0{,}0141) + u_5(0{,}5833)$

$U[g(A_4)] = u_1(0{,}2667) + u_2(0{,}8000) + u_3(0{,}7381) + u_4(0{,}7647) + u_5(0{,}3500)$

$U[g(A_5)] = u_1(0{,}1333) + u_2(1) + u_3(1) + u_4(0{,}5000) + u_5(1)$
$U[g(A_6)] = u_1(1) + u_2(0{,}7333) + u_3(0{,}6667) + u_4(0{,}5059) + u_5(0{,}3333)$

$U[g(A_7)] = u_1(0{,}7000) + u_2(0{,}3333) + u_3(0{,}2857) + u_4(0{,}1788) + u_5(0{,}3333)$

$U[g(A_8)] = u_1(0{,}8000) + u_2(0{,}6667) + u_3(0{,}6667) + u_4(1) + u_5(0{,}7778)$

$U[g(A_9)] = u_1(0{,}3667) + u_2(0{,}8667) + u_3(0{,}3810) + u_4(0{,}9765) + u_5(1)$

$U[g(A_{10})] = u_1(0{,}1667) + u_2(0{,}6667) + u_3(0{,}2619) + u_4(0{,}2000) + u_5(0{,}7778)$

Then utility values of each alternative are calculated using linear interpolation in Eq.(7) as:

$U(A_1) = 0{,}4286\, u_{12} + 0{,}4841\, u_{32} + 0{,}1814\, u_{42} + 0{,}0752\, u_{52} + \sigma_1$

$U(A_2) = 0{,}5454\, u_{22} + 0{,}5805\, u_{33} + 0{,}4195\, u_{34} + 0{,}2772\, u_{42} + 0{,}9995\, u_{53} + 0{,}0005\, u_{54} + \sigma_2$

$U(A_3) = 0{,}1427\, u_{12} + 0{,}5454\, u_{22} + 0{,}9675\, u_{33} + 0{,}0325\, u_{34} + 0{,}8749\, u_{52} + 0{,}1251\, u_{53} + \sigma_3$

$U(A_4) = 0{,}8573\, u_{12} + 0{,}8179\, u_{23} + 0{,}1821\, u_{24} + 0{,}0642\, u_{32} + 0{,}9358\, u_{33} + 0{,}9537\, u_{44} + 0{,}0463\, u_{45} + 0{,}0752\, u_{52} + \sigma_4$

$U(A_5) = 0{,}2855\, u_{12} + u_{24} + u_{34} + 0{,}028\, u_{42} + 0{,}972\, u_{43} + u_{54} + \sigma_5$

$U(A_6) = u_{15} + 0{,}0907\, u_{22} + 0{,}9093\, u_{23} + 0{,}3545\, u_{32} + 0{,}6455\, u_{33} + 0{,}0041\, u_{42} + 0{,}9959\, u_{43} + \sigma_6$

$U(A_7) = 0{,}2855\, u_{13} + 0{,}7145\, u_{14} + 0{,}2726\, u_{22} + 0{,}0967\, u_{32} + 0{,}6684\, u_{42} + \sigma_7$

$U(A_8) = 0{,}8568\, u_{14} + 0{,}1432\, u_{15} + 0{,}3633\, u_{22} + 0{,}6367\, u_{23} + 0{,}3545\, u_{32} + 0{,}6455\, u_{33} + u_{45} + 0{,}9995\, u_{53} + 0{,}0005\, u_{54} + \sigma_8$

$U(A_9) = 0{,}7141\, u_{12} + 0{,}2859\, u_{13} + 0{,}545\, u_{23} + 0{,}455\, u_{24} + 0{,}4841\, u_{32} + 0{,}0942\, u_{44} + 0{,}9058\, u_{45} + u_{54} + \sigma_9$

$U(A_{10}) = 0{,}4286\, u_{12} + 0{,}3633\, u_{22} + 0{,}6367\, u_{23} + 0{,}7545\, u_{42} + 0{,}9995\, u_{53} + 0{,}0005\, u_{54} + \sigma_{10}$

The mathematical model given in Eq. (8) is solved by WinQSB software which is used for the solutions of the operations research and management science problems. In this model δ value is considered as 0,01. Finally the utility values of the alternatives are calculated by using the results of the mathematical model:

$U[g(A_1)] = 0$; $U[g(A_2)] = 0{,}1096$; $U[g(A_3)] = 0{,}0565$; $U[g(A_4)] = 0{,}1197$
$U[g(A_5)] = 0{,}4182$; $U[g(A_6)] = 0{,}3983$; $U[g(A_7)] = 0{,}0464$; $U[g(A_8)] = 0{,}4282$
$U[g(A_9)] = 0{,}4082$; $U[g(A_{10})] = 0{,}0664$

Ranking order of the alternatives is obtained as A_8–A_5–A_9–A_6–A_4–A_2–A_{10}–A_3–A_7–A_1 considering the utility values of the alternatives. According to the ranking order A_8 and A_1 are the most and least preferred alternatives respectively.

4. Conclusion

Nowadays companies get help from consultants for implementing quality assurance systems. Because hiring a consulting firm is a competitive advantage tool in terms of saving time, decrasing cost, improving the quality of products and services and organizational effectiveness. Therefore the selection of an efficient consulting firm becomes a key success factor. The selection process is a complex and a time consuming because of the numerous alternatives and various criteria which are often in conflict with one another. In this paper the application of UTA method is presented for selecting the efficient consulting firm of a textile company. UTA method considers preference of the decision makers on alternatives and uses linear programming model to obtain a utility function having a minimum deviation from the preferences.

Firstly, the committee determines the alternatives and the selection criteria. After collecting alternatives data on the five criteria, steps of UTA method begin. Each criterion range is divided into equal segments and the marginal utility of an alternative is computed. Then the marginal utility functions of an alternative are computed with the linear programming and the results are used for determining utility value of each alternative. Finally, the ranking order of alternatives is obtained by the help of the utility values of alternatives. According to the results, it is advised to the company to select the consulting firm A_8. The firm's management has found the results satisfactory and decided to select A_8.

The proposed approach provides several advantages to decision makers. The UTA method provides estimation of utility function and allows the decision makers to rank the alternatives practically and efficiently. UTA method considers quantitative and qualitative criteria of the decision problem simultaneously. Furthermore, it solves the decision problems with having interdependence between criteria and also this method does not require the criteria weights. But difficult part of the decision problem related with criteria is finding appropriate criteria. The selection criteria change from company to company because of the different needs for the consulting firms. Solving UTA method is easier through the aid of available software.

In future studies, the number of the evaluation criteria and the alternatives may be changed according to needs of the company for the consulting firm. Criteria weights may be added to the method. Other MCDM methods or variants of UTA method may be used for consulting firm selection and the results may be compared with the UTA method results or UTA method may be integrated other MCDM methods. Finally, the proposed approach can also be applied to other strategic MCDM problems of the company.

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