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MAKING COMPARISON BETWEEN FMCDM AND MCDM TO DEFINE PROJECT ACTIVITIES WEIGHTS

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Abstract

This paper combines a group analytic hierarchy process (GAHP) and technique of order performance by similarity to ideal solution (TOPSIS) in fuzzy or non-fuzzy form to define project activities weight factors. For this purpose, a project with 121 activities is proposed as a case. Critical parameters that are affecting the priority of each activity are recognized and weighted by GAHP in its fuzzy or non-fuzzy forms. These weights are subsequently used as the inputs for TOPSIS in its fuzzy or non-fuzzy forms to define the project activities weights. Then activities are affected by the weights and the S-curves of the two new fuzzy and non-fuzzy methods are drawn to compare with the two accepted traditional ones – Bill of quantity (BOQ) and Milestones methods. Finally for mathematical comparing the two new methods and the two traditional ones, analyze of variance method is used. The results are shown that the two new methods are valid and the non-fuzzy one is better than the fuzzy one.

Introduction and Literature Review

Approximately, all researches define the schedule, cost and quality as the three traditional main criteria, directly affect the project success [1-5]. Simplicity and ever remaining within the project organization realm make the traditional approach attractive for a project manager. The major drawback of traditional approach is its inaccurate behavior [1, 3, 6]. Separately considering schedule and cost not only depict many weaknesses in each of them but also, causes duplicated manipulation of the same data for different usage [7]. So, several models like weighted percent complete model [8, 9], Work package model [10], Teicholz's model [11], Steven's curve model [12], Rasdorf's and Abudayyeh's study [9] and earned value model [13] are proposed to combine them.

Paolini and Glaser in 1977 [14], DeCotti and Dyer in 1979 [15] and Pinto and Slevin in 1988 [6], denoted the customer satisfaction as the other project success factor. Type of the projects and human factor are the other critical factors that affect the project success [1, 5, 16]. Shenhar et al. [3] in 1997 introduced thirteen success measures in four groups and some researchers denoted that a payment to contractors is the other project success factor [17, 18, 19, 20].

It is clear that the project success is tracked with actual progress of the project in comparison with the baseline schedule in the project lifecycle [18, 19, 20]. In this case, there are two main methods named as Milestones and BOQ methods where contractor prefers the BOQ method and owner prefers the other one. The significant difference between these methods [8] denotes the necessity of defining new method. Golpîra and Moradi in 2011 [4, 21] introduced a new method by using TOPSIS and GAHP. Alternatively, they made use of these two methods in their fuzzy form to have trade of with vagueness and uncertainty of the method [22].

In order to rank the methods, in this paper the two traditional methods and the two recent ones are compared with together. For this purpose, the S-curve and hypothesis analysis are widely used as the graphical and statistical tools to demonstrate the usefulness, creditability and accuracy of the models. The planed schedule which is taking from literature of the research is used to have the same base in methods comparing.

In following paragraphs the GAHP, FGAHP, TOPSIS, and FTOPSIS are briefly addressed and then the methods compared with together. The methods are completely defined in references number [4, 21, 22].

Principles of GAHP and FGAHP

AHP, introduced by Saaty in 1980 is a multiple criteria decision making (MCDM) method that can determine the priorities among various criteria [23]. Saaty believed that some uncertainty is lying in the nature of the method [24]. Bellman and Zade in 1970 were the first to study the fuzzy decision making problem [25]. Buckely in 1985 was the first to study FAHP technique [26]. Moreover, Tanino in 1984 [27], Bezdek et al. in 1985 [28], and Kacprzyk et al. in 1993 [29] address the group MCDM methods.

Fuzzy and non-fuzzy AHP are started with translating the problem into a hierarchy with a top goal, criteria, sub-criteria and decision alternatives [30]. The comparison matrix (D) of each decision maker (DM) is constructed [30, 31] and the eigenvector and $\lambda_{\max}$ are evaluated by $|D-\lambda.I|=0$. This leads the problem into the consistency index (CI) and consistency ratio (CR) for each DMs comparison matrix by $CR=CI/RI, CI=\lambda_{\max}-n/n-1$. The CR must be less than 0.1; otherwise the DM should revise his/her judgments [4, 21, 22]. Hereafter, the route of FGAHP and GAHP are deferred as follows:

- In GAHP weight of each factor is calculated by Eigenvector technique and then consolidated by geometric mean method [4, 21].
- In FGAHP the comparative weights are transformed to fuzzy triangular numbers. In order to this transforming, in this paper the Gumus method is used [32]. The weights of criteria for each DM and consolidated group decision are calculated by geometric mean method to attain the $\tilde{w}=(\tilde{w}_1,\tilde{w}_2,...,\tilde{w}_i,...,\tilde{w}_n), \tilde{w}_i=(l_i,m_i,u_i)$ as the criteria fuzzy weight vector [22, 26].

Principles of TOPSIS and FTOPSIS

Hwang and Yoon in 1981[33] proposed TOPSIS model to order performance by similarity to ideal solution [22]. But it is difficult for DMs to assign accurate performance rating

to alternatives [34], and therefore the fuzzy logic is used which is lead the decision making close to the real world [35, 36].

- The TOPSIS model is started with defining decision matrix (D'), Standardizing and then normalizing it ($N_{D'}$). The criteria weight vector –that is recalled from result of GAHP in previous step- is multiplied by $N_{D'}$. The ideal (A^+) and nadir ideal (A^-) alternatives are defined and distance measures over each criterion to both ideal (d_i^+) and nadir ideal (d_i^-) are developed and the ratio cl_{i+} is evaluated by $cl_{i+} = C_i = \frac{d_i^-}{d_i^+ - d_i^-}$. Finally to make the ratios useful for using in planed schedule, they are all normalized in the range of [0 1] as the weights of activities [4, 21, 37].
- Like the TOPSIS model, The FTOPSIS model is started with defining fuzzy decision matrix. In this paper the rule of thumb is used to translate the decision matrix to fuzzy decision matrix with triangular fuzzy numbers $(\tilde{t}_{ij})$ as its elements. The matrix is normalized $(\tilde{T})$ and then the standardized fuzzy weighted decision matrix is developed by $V = [\tilde{v}_{ij}] = [\tilde{w}_i \tilde{t}_{ij}]$. Fuzzy negative $\tilde{v}_j^- = (0,0,0)$ and fuzzy positive $\tilde{v}_j^+ = (1,1,1)$ ideals are assigned and the decision of each alternative from fuzzy negative and fuzzy positive ideals. The closeness coefficients are calculated and they are all normalized in the range of [0 1] as the fuzzy weights of activities [22, 30].

Empirical Example

As an empirical study, the planed schedule which is taking from literature of the research is widely used to have the same base in methods comparing. The data for this study were collected in winter 2010 in Kurdistan. The project contains 121 activities in 4 WBS levels when three types of DMs were asked for establishing WBS and time-scaled plan in MSP software. Evaluation process is demonstrated as follows:

GAHP and FGAHP in practice

The hierarchical structure is portrayed in Figure 1 and DM's judgment about criteria, λ_{max} and CR for all three DMs are illustrated in Table 1.

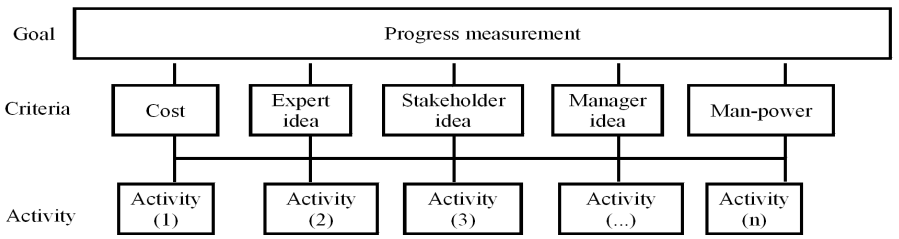

Figure 1. The case study problem's decision-making hierarchy

Following the GAHP process, lead the method to develop the consolidated criteria weight that is W=(0.4341, 0.1272, 0.1844, 0.1236, 0.0884). Similarly, following the FGAHP process, lead the method to evaluate the consolidated weight as illustrated in Table 2.

TOPSIS and FTOPSIS in Practice

The data are gathered by using a special format and then Five-point Likert as used to transform quantitative performance ratings to qualitative ones. Fallowing the TOPSIS model lead us to attain the activity weights as shown in Table 3 -column NFMW- and installing the FTOPSIS is lead us to gain the fuzzy weights as simultaneously illustrated in Table 3 – column FMW.

Table 1

Three DMs pairwise comparison matrix of criterion

$DM^{1,2,3}$	Cost (BCWP)			Experts Idea			Stakeholder Idea			Manager Idea			Man-power		
	DM			DM			DM			DM			DM		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Cost (BCWP)	1	1	1	5	2	0.5	3	2	0.5	3	5	0.6	7	7	0.2
Experts Idea	0.2	0.5	2	1	1	1	1/3	0.5	3	0.5	3	5	2	2	1
Stakeholder Idea	1/3	0.5	2	3	2	1/3	1	1	1	2	3	1	3	5	0.5
Manager Idea	1/3	0.2	1/0.6	2	0.5	0.2	0.5	0.2	1	1	1	1	2	2	0.5
Man-power	1/7	1/7	5	0.5	0.5	1	1/3	0.2	2	0.5	0.5	2	1	1	1
	DM^1			λ_{max} : 5.09						CR: 0.019					
	DM^2			λ_{max} : 5.10						CR: 0.022					
	DM^3			λ_{max} : 5.23						CR: 0.052					

Table 2

Consolidated fuzzy criteria weights

	Fuzzy weight $(\widetilde{w})$
Cost (BCWP)	(0.1413, 0.2451, 0.4527)
Experts Idea	(0.0925, 0.1653, 0.3128)
Stakeholder Idea	(0.1071, 0.1928, 0.3593)
Manager Idea	(0.6103, 0.1091, 0.2064)
Man-power	(0.5940, 0.1004, 0.1903)

Comparison between the Two Proposed Methods and the Previous Ones

The S-curve for cash flow of the case by using Milestone, BOQ, and the two proposed methods are extracted. The results are graphically illustrated in Figure 2.

Figure 2 shows that the S-curves of the proposed methods stand near the S-curves of two traditional methods. The adjustments are demonstrated statistically by using hypothesis analysis that is illustrated in Table 4.

Hypothesis analysis in Table 4 shows the significant difference between BOQ and Milestone methods and also the insignificant differences between the two proposed methods and any of the two traditional ones. So we can correctly use the proposed method instead of the BOQ and Milestone methods. Moreover, one can see that if α is approximately equal to 0.09 – pessimistic think in comparison with $\alpha = 0.05$ – the non-fuzzy method is still being a substitution of the two traditional methods – the null hypothesis is still accepted. But with this new α the null hypothesis is rejected in the case of fuzzy method. So, the hypothesis results show that in this case, the proposed non-fuzzy model stands in the better position in comparison with the fuzzy method.

Conclusion

In this paper, the two new comprehensive methods, one of them is using the GAHP and TOPSIS and the other one is using the FGAHP and FTOPSIS, are proposed in order to define the activity weights of projects. The results show superiority of the two proposed methods in case of comprehensiveness and flexibility in comparison with the other methods. Moreover, superiority of the methods is compared with the traditional methods. The results show that in this case, the non-fuzzy method is the better substitution for the two traditional ones.

Table 3

Activities Weights Evaluated by MCDM and FMCDM

ID	NFMW	FMW	ID	NFMW	FMW	ID	NFMW	FMW	ID	NFMW	FMW
1	3.133	0.78	31	3.912	0.78	61	0.307	0.85	91	0.199	0.84
2	0.748	0.84	32	0.377	0.78	62	0.22	0.84	92	0.199	0.84
3	0.12	0.69	33	0.266	0.9	63	0.417	0.8	93	0.199	0.84
4	0.256	0.8	34	0.308	0.84	64	0.22	0.84	94	0.143	0.74
5	5.299	1.08	35	0.272	0.78	65	0.22	0.84	95	0.143	0.74
6	0.351	0.84	36	0.474	0.69	66	0.307	0.84	96	0.194	0.74
7	0.199	0.74	37	0.2	0.78	67	0.22	0.84	97	0.194	0.74
8	0.252	0.8	38	0.404	0.88	68	0.417	0.8	98	0.38	1
9	5.688	0.98	39	0.553	1	69	0.273	0.84	99	0.269	0.84
10	0.22	0.84	40	2.114	0.88	70	0.273	0.84	100	0.336	0.88
11	0.15	0.74	41	0.315	0.94	71	0.371	0.94	101	0.288	0.76
12	0.583	0.84	42	0.315	0.94	72	0.22	0.84	102	0.224	0.72
13	0.166	0.78	43	0.171	0.84	73	0.457	0.9	103	0.191	0.67
14	11.33	1.17	44	0.315	0.94	74	0.215	0.84	104	0.322	0.9
15	0.821	0.8	45	0.255	0.8	75	0.171	0.84	105	0.274	0.84
16	0.307	0.69	46	0.225	0.84	76	0.311	0.9	106	0.264	0.78
17	5.679	0.98	47	0.22	0.84	77	0.137	0.69	107	0.287	0.76
18	3.189	0.72	48	0.338	0.9	78	0.245	0.84	108	0.224	0.72

ID	NFMW	FMW	ID	NFMW	FMW	ID	NFMW	FMW	ID	NFMW	FMW
19	0.138	0.78	49	0.262	0.84	79	0.245	0.84	109	0.191	0.67
20	3.127	0.69	50	0.189	0.69	80	0.245	0.84	110	0.371	0.94
21	0.125	0.78	51	0.22	0.84	81	0.245	0.84	111	0.269	0.84
22	22.79	1.63	52	0.329	0.8	82	0.746	0.9	112	0.264	0.78
23	1.085	0.84	53	0.262	0.85	83	0.236	0.84	113	0.288	0.76
24	0.872	0.78	54	0.199	0.75	84	0.302	0.88	114	0.224	0.72
25	0.221	0.84	55	0.22	0.84	85	1.117	1	115	0.101	0.67
26	0.15	0.74	56	0.244	0.74	86	0.318	0.9	116	0.371	0.94
27	0.793	0.69	57	0.199	0.74	87	0.318	0.9	117	0.269	0.84
28	0.295	0.69	58	0.427	0.9	88	0.318	0.9	118	0.264	0.78
29	0.537	0.69	59	0.199	0.74	89	0.318	0.9	119	0.288	0.76
30	0.223	0.69	60	0.199	0.74	90	0.199	0.84	120	0.224	0.72
									121	0.101	0.67

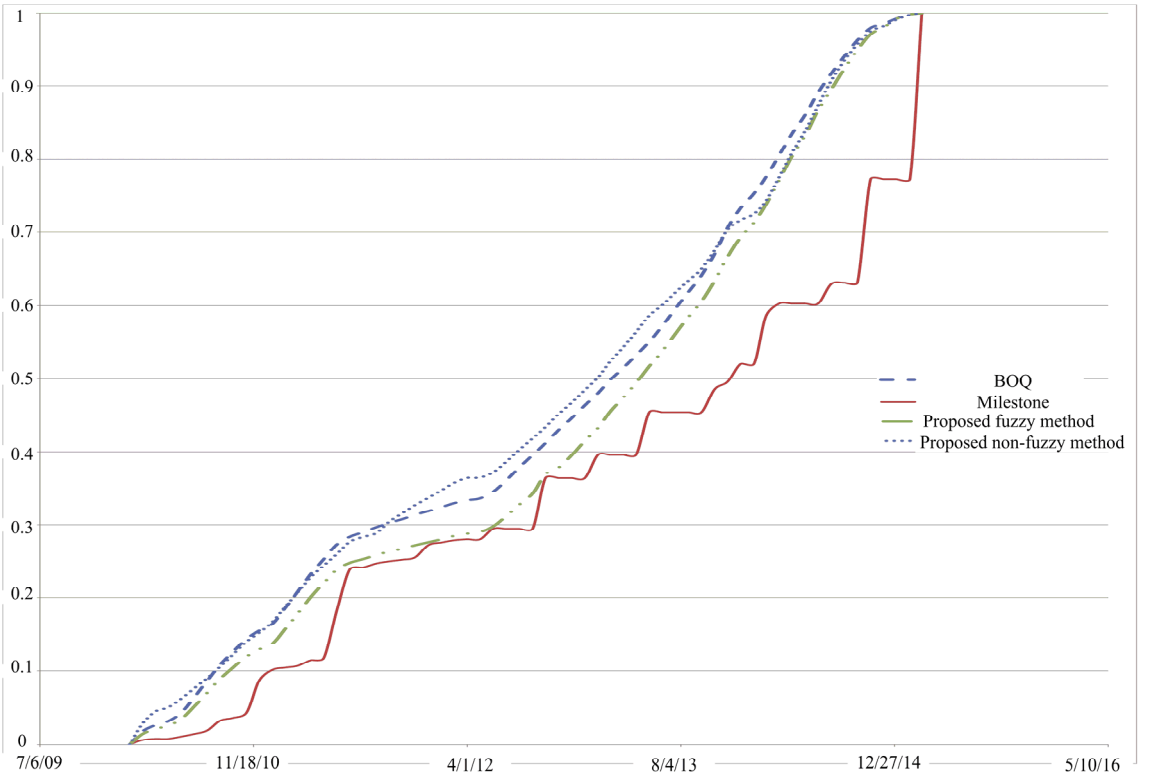

Figure 2. S-curves of milestone, BOQ and proposed methods

Table 4

Hypothesis results

BOQ method can substituted by Proposed non-fuzzy method	Null hypothesis is accepted	BOQ vs. Proposed non-fuzzy	$Z_{\alpha/2} > (Z = 0.7188)$
Milestone method can substituted by Proposed non-fuzzy method	Null hypothesis is accepted	Milestone vs. Proposed non-fuzzy	$Z_{\alpha/2} > (Z = 1.6995)$
Milestone method cannot substituted by BOQ method	Null hypothesis is not accepted	BOQ vs. Milestone	$Z_{\alpha/2} < (Z = 2.0360)$
BOQ method can substituted by Proposed fuzzy method	Null hypothesis is accepted	BOQ vs. Proposed fuzzy	$Z_{\alpha/2} > (Z = 0.0148)$
Milestone method can substituted by Proposed fuzzy method	Null hypothesis is accepted	Milestone vs. Proposed fuzzy	$Z_{\alpha/2} > (Z = 1.9390)$
$\alpha = 0.05 \Rightarrow Z_{\alpha} = 1.96$			

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