Application of TOPSIS and Group AHP for Project Management

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Abstract: Eliminating impacts of all variables that influence the projects turns out to be not possible. Thus, managers must be able to manage variables and also their effects. Recent project control methods cannot consider all of criteria which affect projects and are not desirable for all projects main elements. This paper proposes a new comprehensive method to calculate a progress of projects. The method uses any factors which affect the projects in order to increase accuracy and flexibility and also ensures the integrity of projects. To achieve this purpose, activities of projects are weighted by GAHP and TOPSIS methods. Efficiency of the proposed method has been verified on a stadium practical project. The results are illustrated by S-curve and also proved by analyze of variance.
Keywords: Project management, S-curve, MCDM, Hypothesis.

1. INTRODUCTION

Recent researches reveal that schedule, cost and quality are traditional main criteria, directly affect the projects [1]. Earned value method (EVM) introduced by Eldin [2] combines time and cost, simultaneously. Barber et al. [1] address a human factor as another critical factor. Freeman et al. [3] introduce type of project as the main criterion which also affects it. Shenhar et al. [2] believe that a project success is a multi-dimensional multi-criteria matter that is related to various views of different peoples and even changes with time. Moreover, some studies introduce a payment to contractors as another critical parameter in project success [4].

All the mentioned criteria should be evaluated by the project progress measurement. Project progress measurement is already calculated based on bill of quantities (BOQ) and Milestones methods. Although owner and contractors select their desired method, there is significant difference between these two methods [5].

This paper proposes a new advanced weighting method that considers all the main factors to achieve the reliable progress measurement. In this method, group analytic hierarchy process (GAHP) and technique for order-preference by similarity to ideal solution (TOPSIS) models are used to integrate all the qualitative or quantitative parameters in an index, named activity weight factor.

2. PROBLEM MODELING

A. Principles of GAHP

AHP is a powerful method in decision making, firstly introduced by Saaty [5]. AHP in group form, called GAHP, is used to follow the team work essence of project. The key practical steps involved in developing GAHP are: (1) Translate the problem into a hierarchy (2) Construct pairwise comparison matrix that is shown in (1), where *k* is the counter of DMs

$$D^k = \begin{bmatrix} x^k_{11} & \cdots & x^k_{1n} \\ \vdots & \ddots & \vdots \\ x^k_{n1} & \cdots & x^k_{nn} \end{bmatrix} \quad (1)$$

(3) Calculate Eigenvector and λ_{max} by (2), then define consistency index (CI) for each decision maker (DM) by (3). CI could be less than 0.1. If this is not the case, DM must review his/her judgment

$$|D - \lambda . I| = 0 \quad (2)$$

$$CI = {}^{\lambda_{max} - n}\!/_{n-1} \quad (3)$$

(4) Extract comparative weight of each criterion by Eigenvector technique that is shown in (4). This technique uses λ_{max} to determine criterion weights. If criteria denote by C_i and their weights denote by W_i, then the matrix D defines by (4), represents the pairwise comparison. In (4), vector W can be calculated by (5) that using increasing η for matrix D and normalizing results until the consistency in W is achieved [5].

$$(D - \lambda_{max} I)W = 0 \quad (4)$$

$$W = \lim_{\xi \longrightarrow \infty} ({}^{D^\eta . \xi}\!/_{\xi^t . D^\eta . \xi}) \quad (5)$$

B. Principles of TOPSIS

Hwang and Yoon [6] firstly developed the TOPSIS method in 1981. The key practical steps involved in developing the TOPSIS are: (1) Calculate normalized ratings by (6)

$$n_{ij} = r_{ij} \Big/ \sqrt{\sum_{i=1}^{m} r_{ij}^{\,2}} \quad i = 1,...,m \;,\; j = 1,...,n \tag{6}$$

(2) Calculate weighted normalized ratings by (7), where W is predefined by AHP,

$$V = ND.W_{nxn} = \begin{bmatrix} V_{11} & \cdots & V_{1n} \\ \vdots & \ddots & \vdots \\ V_{m1} & \cdots & V_{mn} \end{bmatrix} \tag{7}$$

(3) Identify positive-ideal and negative-ideal solutions as shown in (8), (4) Calculate separation measures by (9)

$$A^{+} = \{(\max_i V_{ij} \,|\, j \in J), (\min_i V_{ij} \,|\, j \in J') | i = 1,2,...,m\}$$
$$A^{-} = \{(\min_i V_{ij} \,|\, j \in J), (\max_i V_{ij} \,|\, j \in J') | i = 1,2,...,m\} \tag{8}$$

$$d_{i+} = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_i^{+})^2}; i = 1,2,...,m\}$$
$$d_{i-} = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_i^{-})^2}; i = 1,2,...,m \tag{9}$$

(5) Calculate similarities to positive-ideal solution by (10)

$$cl_{i+} = C_i = \frac{d_i^-}{d_i^+ - d_i^-}; 0 < cli + < 1; i = 1,2,...,m \tag{10}$$

In the proposed weighting method, cl_{i+} is normalized and used as the weight factor of each activity [5], [6].

3. Empirical Example

As an empirical example, a stadium project is proposed to demonstrate validity of the method. The data for the study were collected by 2010 in Kurdistan, Iran. The project contains 121 activities in 4 WBS levels. Three types of DMs were asked for establishing WBS and time-scaled plan in MSP software. Evaluation process is demonstrated as follows:

After translating the problem into a hierarchy that shown in Fig. 1, DM's judgment about criteria, λ_{max} and CI are calculated for all DMs. Results are shown in Table 1.

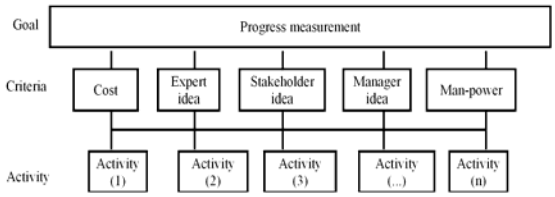

Figure 1: The case study problem's decision-making hierarchy

TABLE 1
THREE DMS PAIRWISE COMPARISON MATRIX OF CRITERION

DM^1	λ_{max} : 5.08	CI:0.022
DM^2	λ_{max} : 5.09	CI:0.025
DM^3	λ_{max} : 5.23	CI:0.058

After completing the predetermined AHP steps, W vector is calculated in (11) and consequently used in TOPSIS method to calculate activities weight factors as shown in Table 2.

W=(0.4355,0.1317,0.1983,0.1285,0.1060) (11)

4. Comparison Between Proposed Method and The Previous Ones

Finally S-curves for cash flow of the stadium plan are plotted by Milestone, BOQ, and the proposed method. The results are compared in Fig. 2.

TABLE 2
MCDM RESULTS AND ACTIVITIES WEIGHTS

A	W_i	A	W_i	A	W_i	A	W_i	A	W_i	A	W_i
1	0.78	21	0.78	41	0.94	61	0.85	81	0.84	101	0.76
2	0.84	22	1.63	42	0.94	62	0.84	82	0.9	102	0.72
3	0.69	23	0.84	43	0.84	63	0.8	83	0.84	103	0.67
4	0.8	24	0.78	44	0.94	64	0.84	84	0.88	104	0.9
5	1.08	25	0.84	45	0.8	65	0.84	85	1	105	0.84
6	0.84	26	0.74	46	0.84	66	0.84	86	0.9	106	0.78
7	0.74	27	0.69	47	0.84	67	0.84	87	0.9	107	0.76
8	0.8	28	0.69	48	0.9	68	0.8	88	0.9	108	0.72
9	0.98	29	0.69	49	0.84	69	0.84	89	0.9	109	0.67
10	0.84	30	0.78	50	0.69	70	0.84	90	0.84	110	0.94
11	0.74	31	0.78	51	0.84	71	0.94	91	0.84	111	0.84
12	0.84	32	0.78	52	0.8	72	0.84	92	0.84	112	0.78
13	0.78	33	0.9	53	0.85	73	0.9	93	0.84	113	0.76
14	1.17	34	0.84	54	0.75	74	0.84	94	0.74	114	0.72
15	0.8	35	0.78	55	0.84	75	0.84	95	0.74	115	0.67
16	0.69	36	0.69	56	0.74	76	0.9	96	0.74	116	0.94
17	0.98	37	0.78	57	0.74	77	0.69	97	0.74	117	0.84
18	0.72	38	0.88	58	0.9	78	0.84	98	1	118	0.78
19	0.78	39	1	59	0.74	79	0.84	99	0.84	119	0.76
20	0.69	40	0.88	60	0.74	80	0.84	100	0.88	120	0.72
										121	0.67

Figure 2: S-curves of milestone, BOQ and proposed method

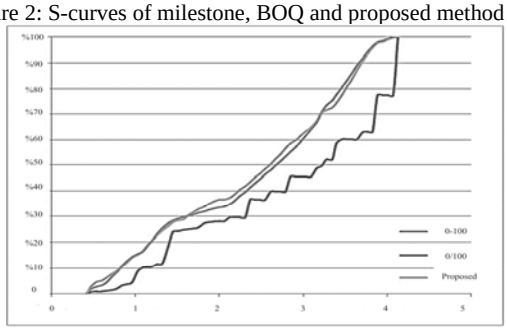

Fig. 2 clearly reveals the adjustment in the proposed method. The adjustment is also demonstrated by using hypothesis analysis that is illustrated in Table 3.

TABLE 3
HYPOTHESIS RESULTS

Statistical analysis			Conclusion $\alpha = 0.05 \Rightarrow Z_{\alpha/2} = 1.96$	
BOQ	Mean	339843828.6	BOQ vs. Proposed	$Z_{\alpha/2} > Z$
	Variance	2.03602E+16		
Proposed	Mean	339298650.7	Milestone vs. Proposed	$Z_{\alpha/2} > Z$
	Variance	2.27465E+16		
Milestone	Mean	202336231.5	BOQ vs. Milestone	$Z_{\alpha/2} < Z$
	Variance	1.36928E+17		
BOQ vs. Proposed	S=1347086316408480		BOQ vs. Proposed	Null hypothesis is accepted
	Z = 0.0148539			
Milestone vs. Proposed	S=49898340772269 10		Milestone vs. Proposed	Null hypothesis is accepted
	Z=1.9389131952459			
BOQ vs. Milestone	S=4915263365418740		BOQ vs. Milestone	Null hypothesis cannot accepted
	Z=1.961341856530 75			

Table 3 shows the significant difference between BOQ and Milestone and also the insignificant difference between the proposed method and any of the two traditional ones. So, the proposed method could be replaced by the traditional ones with high relibility.

5. References

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