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REAL PROJECT SUCCESS MEASUREMENT BY USING DATA ENVELOPMENT ANALYSIS

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Abstract

This paper addresses the realistic model for project success measurement. The proposed scheme defines a reliable weight factor for projects activities in order to gain the upper level of accuracy in the term of project measurement as the important factor for managing projects. The method accurately considers all of the project success factors in any type of project by using data envelopment analysis (DEA) method with ideal decision making unit (IDMU) and anti-ideal decision making unit (ADMU). This makes it not only more comprehensive, flexible and reliable method in comparison with the other previous ones but also preferable by all projects main elements. Empirical results show the viability of the proposed method.

Introduction and Literature Review

Success of a project depends on well-defining the schedule, cost and quality as the three traditional main criteria, directly affect the project success [1]. The closeness of schedule and cost leads researchers proposes several models by combining those two criteria [2]. As well as the cost, several researchers explore human factor [1], type of project [3] and customer satisfaction as project success critical factors [4]. Moreover, the success is initiated as a multi-dimensional multi-criteria approach [3], which leads Golpîra proposes a new comprehensive method based on fuzzy multi-criteria decision making in 2011 [5]. Golpîra and Moradi, also develops a method based on multi-criteria decision making in 2011 [6, 7].

Monitoring and controlling these criteria, which is based on project progress measurement is the most important term. Project progress measurement not only directly affects the project success, but also used as the base of payment to contractor, which is done based on two methods named Milestones (0/100) and bill of quantity (BOQ or 0-100) methods. It is proved that there is significant difference between these two methods and it is the challenge. In this case, Hughes in 1986 provides six cusses for projects failures that contain poor attention on the project management system [8]. Brooks in 1995 introduces the submission to the unrealistic customers due date and poor monitoring of project progress as the two cusses for failure in IT projects [9]. Black in 1996 introduces the poor planning, project changes and poor scheduling as the three cusses for failure in projects [10].

In addition to these researchers, Browne (2001), Pitagorsky (2001), Matta and Ashkenas (2003) Neimat (2005) and Golpîra (2011) point out the success factors of projects and note the cusses of projects failures [5, 6, 7].

This paper proposes an advanced weighting method that considers all of the main factors to achieve the correct progress measurement. The method accurately considers all of the project success factors in any type of project by using DEA method with IDMU and ADMU. The rest of this paper organized as follows. Section 2 describes the model in detail. In section 3, simulation details and results are explained and finally, section 4 concludes the paper.

Principles of DEA Method with IDMU and ADMU

Charnes et al. [11] introduced DEA to evaluate decision making units (DMUs) from the best one [12]. Entani et al. [13] and Wang et al. [14] developed the model until Wang et al. [12] proposed their model based on the relative closeness (RC) to the IDMU that may used for ranking of all DMUs [12]. This recent advanced method is used in this paper, which is introduced bellow:

Assume that there are n DMUs to be evaluated. Each of them consumes m inputs, denoted by $x_{ij}\,(i = 1,..., m, j = 1,..., n)$, to produce s outputs denoted by $y_{rj}\,(i = 1,..., s, j = 1,..., n)$. Then, an IDMU may be the DMU that can use the least inputs, $x_i^{\min}\,(i = 1,..., m)$, to produce the most outputs, $y_r^{\max}\,(r = 1,..., s)$, while an ADMU consume the most inputs, $x_i^{\max}\,(i = 1,..., m)$, to make the least outputs, $y_r^{\min}\,(r = 1,..., s)$.

To completing the model, the LP model shown in Eq. (1) and Eq. (2) must be solved for all DMUs such as DMU_0 to calculate the $\theta^*_{j0}, \varphi^*_{j0}$, where j_0 is the DMU under evaluation (denoted by DMU_0), u_r, v_i are decision variables, ε is the non-Archimedean infinitesimal, θ^*_{IDMU} is the optimum efficiency of IDMU that may calculated by Eq. (3) and φ^*_{ADMU} is the worst efficiency of the ADMU that may calculated by Eq. (4).

After this step, the RC index may be calculated to combine the best and the worst possible relative efficiencies, for all DMUs by Eq. (5). It is clear that the bigger the RC_{j0} value, the better the performance of DMU_0 [12].

$$
\begin{aligned}
Max \quad & \theta_{j0} = \sum_{r=1}^{s} u_r y_{rj0} \\
S.T. \quad & \sum_{i=1}^{m} v_i x_{ij0} = 1 \\
& \sum_{r=1}^{s} u_r y_j^{\max} - \sum_{i=1}^{m} v_i (\theta^*_{IDMU} \quad x_i^{\min}) = 0 \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1,..., n \\
& u_r, v_i \ge \varepsilon \qquad \forall r, i
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
&Max \quad \varphi_{j0} = \sum_{r=1}^{s} u_r y_{rj0} \\
&S.T. \quad \sum_{i=1}^{m} v_i x_{ij0} = 1 \\
&\qquad \sum_{r=1}^{s} u_r y_j^{\min} - \sum_{i=1}^{m} v_i (\varphi_{IDMU}^{*} \; x_i^{\max}) = 0 \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1,\ldots, n \\
&\qquad u_r, v_i \ge \varepsilon \qquad \forall r, i
\end{aligned} \tag{2}
$$

$$
\begin{aligned}
&Max \quad \theta_{IDMU} = \sum_{r=1}^{s} u_r y_r^{\max} \\
&S.T. \quad \sum_{i=1}^{m} v_i x_i^{\min} = 1 \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1,\ldots, n \\
&\qquad u_r, v_i \ge \varepsilon \qquad \forall r, i
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
&Max \quad \varphi_{ADMU} = \sum_{r=1}^{s} u_r y_r^{\min} \\
&S.T. \quad \sum_{i=1}^{m} v_i x_i^{\max} = 1 \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1,\ldots, n \\
&\qquad u_r, v_i \ge \varepsilon \qquad \forall r, i
\end{aligned} \tag{4}
$$

$$
RC_{j0} = \frac{\varphi_{j0}^{*} - \varphi_{ADMU}^{*}}{(\varphi_{j0}^{*} - \varphi_{ADMU}^{*}) + (\theta_{IDMU}^{*} - \theta_{j0}^{*})} \tag{5}
$$

Empirical Example

As an empirical study, a building is proposed as an empirical sample of construction projects to demonstrate usefulness of the proposed method. The data for this study were collected in May 2011 in Kurdistan. The project contains 45 activities in 4 WBS levels that are scheduled in Microsoft project software.

As previously explained, DEA may use several inputs and also several outputs. In this paper, man power, cost (without cost of machine and manpower), machine power, total float and duration are used as the inputs and the effect of each activity on quality of project is used as the output of the model. By these data, DEA model lead us to have activities weight factor (WF) as shown in Table 1.

Table 1

Summary of applying DEA model on activities data

DMU	φ*	Θ*	RC	WF	DMU	φ*	Θ*	RC	WF
Activity 1	3.983868	1.63E-02	0.08	0.65	Activity 23	1.898369	2.81E-02	0.04	0.31
Activity 2	0.9979796	6.17E-03	0.02	0.16	Activity 24	3.506774	0.5333186	0.07	0.58
Activity 3	2.571278	1.59E-02	0.05	0.42	Activity 25	2.657979	0.2227359	0.06	0.44
Activity 4	2.085818	7.28E-02	0.04	0.34	Activity 26	11.93014	3.68E-02	0.21	1.68
Activity 5	38.18633	0.26153	0.47	3.68	Activity 27	23.63772	0.1288131	0.35	2.76
Activity 6	19.61288	6.80E-02	0.31	2.44	Activity 28	3.932085	0.4588145	0.08	0.64
Activity 7	14.65174	0.35062	0.25	1.98	Activity 29	5.145933	0.13462	0.10	0.82
Activity 8	74.00567	0.19239	0.63	4.95	Activity 30	1.900858	0.1280524	0.04	0.31
Activity 9	75.13824	0.20338	0.64	4.98	Activity 31	33.02407	0.2587316	0.43	3.40
Activity 10	106.7761	0.21575	0.71	5.58	Activity 32	11.51107	0.9609657	0.21	1.66
Activity 11	7.914768	0.59913	0.15	1.21	Activity 33	3.359401	0.1075177	0.07	0.55
Activity 12	157.0512	0.49167	0.79	6.15	Activity 34	4.785098	3.10E-02	0.10	0.77
Activity 13	1	0.15861	0.02	0.16	Activity 35	15.85441	7.81E-02	0.27	2.09
Activity 14	116.0098	1	0.73	5.74	Activity 36	4.630582	4.39E-02	0.09	0.74
Activity 15	162.3392	0.93393	0.79	6.21	Activity 37	8.28091	2.21E-01	0.16	1.25
Activity 16	8.053274	1	0.16	1.24	Activity 38	2.932299	6.43E-02	0.06	0.48
Activity 17	82.53478	0.41375	0.66	5.15	Activity 39	95.01048	1.00E+00	0.69	5.42
Activity 18	86.83495	0.21644	0.67	5.23	Activity 40	77.63913	5.35E-01	0.64	5.05
Activity 19	5.65442	0.3412	0.11	0.90	Activity 41	19.15277	7.60E-01	0.31	2.42
Activity 20	8.406416	5.54E-01	0.16	1.28	Activity 42	2.768869	5.03E-03	0.06	0.46
Activity 21	65.36616	0.37952	0.60	4.73	Activity 43	1.784115	4.12E-03	0.04	0.29
Activity 22	4.523726	0.65758	0.09	0.74	Activity 44	40.56359	3.23E-01	0.49	3.80
					Activity 45	1	5.73E-03	0.02	0.16
		Θ*(IDMU)	43.25681		φ*(ADMU)	0.10031			

Results and Conclusion

To make a comparison between the method and the two traditional ones, the S-curves of project by applying these three methods are extracted as shown in Fig. 1.

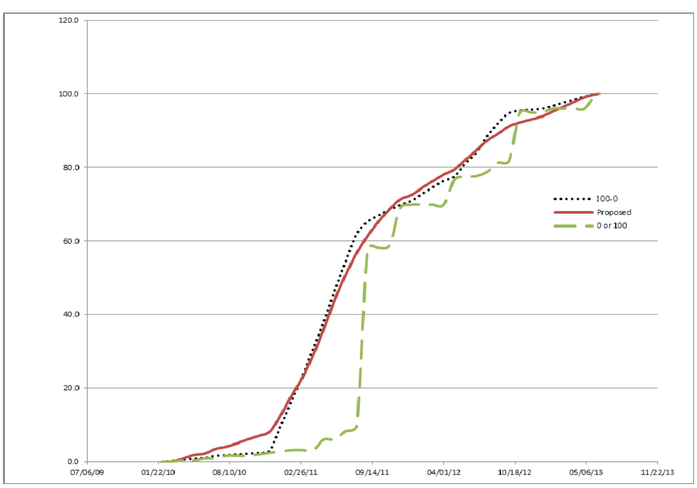

Figure 1. S-curves of milestone, BOQ and proposed method

The achieved adjustment demonstrated mathematically however it clearly indicated in Fig.1. one can see the adjustment not only in the position of the curve in comparison with the other ones, but also in the shape and smoothness of it. This demonstration has been constructed by using hypothesis analysis and the results are illustrated in Table 2.

Table 2

Hypothesis results

Statistical analysis (sample size =20)			Conclusion	
			$\alpha = 0.12 \Rightarrow Z_{\alpha/2} = 1.55$	
BOQ	Mean	23652716216.08	BOQ vs. Proposed	$Z_{\alpha/2} > Z$
	Variance	4370452809278920		
Proposed	Mean	25768473982.8304	Milestone vs. Proposed	$Z_{\alpha/2} > Z$
	Variance	3719323919351940		
Milestone	Mean	92209816106	BOQ vs. Milestone	$Z_{\alpha/2} < Z$
	Variance	3.81367366284307E+22		
BOQ vs. Proposed	S=40448883643154300		BOQ vs. Proposed	Null hypothesis is accepted
	Z=1.51416826726693			
Milestone vs. Proposed	S=1.92868909546793E+21		Milestone vs. Proposed	Null hypothesis is accepted
	Z=0.332669261303247			
BOQ vs. Milestone	S=1.92543345101829E+21		BOQ vs. Milestone	Null hypothesis cannot accepted
	Z=1.56106621676416			

Hypothesis analysis in Table 2 shows the significant difference between two traditional methods (it's proved by previous researches) and also the insignificant differences between the proposed method and any of the two traditional ones. Note that by pessimistically considering α being 0.12, so we can correctly use the proposed method instead of the BOQ and Milestone methods.

In this paper, the usage of DEA with IDMU and ADMU method for defining activities weight factors is examined. The method can consider all of variables that may affect the project progress all together. The simplicity and flexibility of the method and its success in getting agreement of all project elements make it better than the previous ones.

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