

## Project Evaluation Method Based on Matter-Element and Hierarchy Model

Haifeng Li<sup>1,2</sup>

<sup>1</sup>Dalian University of Technology, No.2 Linggong Road, Ganjingzi District, Dalian, 116024, China

<sup>2</sup>Dalian Jiaotong University, No.794 Huanghe Road, Shahekou District, Dalian, 116028, China  
e-mail: haifengli@dlut.edu.cn<sup>1</sup>

### Abstrak

*Evaluasi proyek selalu menjadi kunci dari manajemen proyek rekayasa. Evaluasi proyek adalah pekerjaan yang kompleks yang melibatkan banyak faktor. Hasil evaluasi akhir selalu dipengaruhi langsung oleh definisi indeks evaluasi yang bervariasi dan bobot yang terkait. Makalah ini terutama mempelajari penilaian kemampuan para ahli dan pembentukan sistem evaluasi proyek indeks dalam tinjauan komunikasi mitra, menganalisis secara mendalam pekerjaan peninjauan proyek teknik, membangun sistem evaluasi indeks untuk proyek rekayasa, dan mengajukan metode evaluasi komprehensif berdasarkan pada model elemen-materi dan hirarki dalam proyek rekayasa, akhirnya, menerapkannya dalam proyek yang sebenarnya yang membuktikan kepraktisan teori kertas.*

**Kata kunci:** model materi-unsur dan hirarki, metode evaluasi proyek, tinjauan komunikasi mitra, tinjauan proyek rekayasa

### Abstract

*Project evaluation is always the key link of the engineering project management. Project evaluation is a complex work which involves many factors. The final evaluation result is always influenced directly by the definition of various evaluation indexes and the corresponding weight. Mainly study the judgment of the experts' ability and the establishment of the project evaluation index system in the peer communication review, analyze deeply the engineering project review work, build a evaluation index system for the engineering project, and put forward a comprehensive evaluation method based on the matter-element and hierarchy model in the engineering project, at last, apply it in the actual project which proves the practicability of the paper's theory.*

**Keywords:** engineering project review, matter-element and hierarchy model, peer communication review, project evaluation method

## 1. Introduction

The impartiality of the engineering project review is very important, which most applicants pay close attention to. Nowadays, peer communication review [1] is commonly used in the review work, which means experts of the same field review the project back to back. Peer communication review can take full advantage of scientists who are in the scientific community to realize the reasonable allocation of scientific and technological resources. It also contributes to the democratization of the scientific decision-making, and puts an end to the purely administrative decision-making[2].

This article attempts to establish the evaluation index system of the engineering project, give the knowledge set representation of engineering project knowledge, put forward engineering project evaluation method based on the matter-element and hierarchy model [3], and at last validates it through an actual project.

## 2. Research Method

### 2.1. Project evaluation index system

The evaluation of engineering project involves many factors[4], such as the rationality of project contents, the ability of the executors, and the application prospect of the engineering project, which all need carrying on the comprehensive evaluation. In this paper, we define a

comprehensive evaluation index system for the project to be reviewed. The system contains three comprehensive indexes and ten single indexes, as shown in Table 1.

**Table 1. Project evaluation index system**

Comprehensive index	Single index
Research goal (b1)	Scientific level (c1)
	Expected results (c2)
	Application prospect (c3)
Research content (b2)	Implementation content (c4)
	Technical route (c5)
	Schedule (c6)
	Budget (c7)
Research ability (b3)	Pre-implementation work (c8)
	Implementation ability (c9)
	Implementation conditions(c10)

**2.2. Matter-element representation of project knowledge**

The project as a knowledge carrier, it contains the knowledge is called project knowledge, according to matter-element [5], project knowledge can be represented as,

$$KS_P = (N_P, C, V) = \begin{bmatrix} N_P & c_1 & v_1 \\ & c_2 & v_2 \\ & c_3 & v_3 \\ & \dots & \dots \\ & c_n & v_n \end{bmatrix} \tag{1}$$

where  $N_P$  is project,  $C$  is the project's feature set  $\{c_1, c_2, \dots, c_n\}$ ,  $V$  is quantum set of  $N$  about  $C$   $\{v_1, v_2, \dots, v_n\}$ .

**2.3. Classical domain and section domain**

Classical domain matter-element is defined as

$$R_j = (N_j, C, X_j) = \begin{bmatrix} N_j & c_1 & X_{j1} \\ & c_2 & X_{j2} \\ & \dots & \dots \\ & c_n & X_{jn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & \langle a_{j1}, b_{j1} \rangle \\ & c_2 & \langle a_{j2}, b_{j2} \rangle \\ & \dots & \dots \\ & c_n & \langle a_{jn}, b_{jn} \rangle \end{bmatrix} \tag{2}$$

where  $N_j(j=1,2,\dots,m)$  is the  $j$ -grade status of the review;  $c_i(i=1,2,\dots,n)$  is the corresponding characteristic for a grade status of the review; interval  $X_{ji}=\langle a_{ji}, b_{ji} \rangle$  is the range of the value  $c_i$  for  $N_j$ , namely, the data range of the corresponding index of the each grade of the review status—classical domain.

Section domain matter-element is defined as,

$$R_p = (N_p, C, X_p) = \begin{bmatrix} N_p & c_1 & X_{p1} \\ & c_2 & X_{p2} \\ & \dots & \dots \\ & c_n & X_{pn} \end{bmatrix} = \begin{bmatrix} N_p & c_1 & \langle a_{p1}, b_{p1} \rangle \\ & c_2 & \langle a_{p2}, b_{p2} \rangle \\ & \dots & \dots \\ & c_n & \langle a_{pn}, b_{pn} \rangle \end{bmatrix} \tag{3}$$

where  $N_p$  is the whole evaluation grade;  $c_i(i=1,2,\dots,n)$  is a characteristic of the whole grade; interval  $X_{pi}=\langle a_{pi}, b_{pi} \rangle$  is the range of the value  $c_i$  for  $N_p$ , namely, the data range of the index of the whole review grade---section domain. Obviously, there is  $X_j \subset X_p$ .

## 2.4. Correlation function

Correlation function [6] describes the degree of the required level of the matter-element, giving the matter-element value  $x$  mapping to the real axis in the matter-element analysis evaluation. The distance between node  $x_i$  and limited reality interval  $X = \langle a, b \rangle$  is defined as,

$$\rho(x_i, X) = \left| x_i - \frac{a+b}{2} \right| - \frac{1}{2}(b-a) = \begin{cases} a-x_i & x_i \leq \frac{a+b}{2} \\ x_i-b & x_i > \frac{a+b}{2} \end{cases}, \quad (4)$$

where the distance between node  $x_i$  and interval  $X$  can be negative value, the difference of the negative value determines correspondingly the difference of the position  $x_i$  in the interval  $X$ .

We can get the distance between the node  $x_i$  and the interval  $X_{ji}$  of classical domain, as well as the distance between the node  $x_i$  and the interval  $X_{pi}$  of section domain as,

$$\rho(x_i, X_{ji}) = \left| x_i - \frac{a_{ji}+b_{ji}}{2} \right| - \frac{1}{2}(b_{ji}-a_{ji}) = \begin{cases} a_{ji}-x_i & x_i \leq \frac{a_{ji}+b_{ji}}{2} \\ x_i-b_{ji} & x_i > \frac{a_{ji}+b_{ji}}{2} \end{cases}, \quad (5)$$

$$\rho(x_i, X_{pi}) = \left| x_i - \frac{a_{pi}+b_{pi}}{2} \right| - \frac{1}{2}(b_{pi}-a_{pi}) = \begin{cases} a_{pi}-x_i & x_i \leq \frac{a_{pi}+b_{pi}}{2} \\ x_i-b_{pi} & x_i > \frac{a_{pi}+b_{pi}}{2} \end{cases} \quad (6)$$

Then the computation formula of the correlation function  $K(x)$  is defined as,

$$K_j(x_i) = \begin{cases} \frac{\rho(x_i, X_{ji})}{\rho(x_i, X_{pi}) - \rho(x_i, X_{ji})} & x_i \notin X_{ji} \\ -\frac{\rho(x_i, X_{ji})}{|X_{ji}|} & x_i \in X_{ji} \end{cases}. \quad (7)$$

Correlation function describes the degree of the required level of the matter-element, giving matter-element the value  $x_0$  mapping to the real axis in the matter-element analysis evaluation. Actually, it describes the degree of ownership of the each index of the project to be reviewed about each review grade  $j$ , which makes mathematics "belong" and "not belong" qualitative description the extended to quantitative description.

## 3. Results and Analysis

### 3.1. Project grade comprehensive evaluation

If  $K_{j_0}(N_0) = \max(K_j(N_0))$ ,  $j_0 \in (1, 2, \dots, m)$ ,  $N_0$  belongs to the grade  $j_0$ . The value of the correlation in the real axis is corresponding to the membership degree of the standard grade of the matter-element to be reviewed. The bigger value is, the higher membership degree is.

If  $K_{j_0}(N_0) < -1$ , it means that the matter-element to be evaluated does not meet the requirements of the standard grades, and does not have the conditions to be converted into the standard grades. The smaller its value is, the farther the standard level is away from.

If  $-1 < K_{j_0}(N_0) < 0$ , it means that the matter-element to be evaluated does not meet the requirements of the standard grades, but has the conditions to be converted into the standard grades. The bigger its value is, the more easily it is to be converted into the standard grades.

If  $0 < K_{jo}(N_o) < 1$ , it means that the matter-element to be evaluated meets the requirements of the standard grades.

### 3.2. Project matter-element to be evaluated

If there are  $n$  single indexes in the comprehensive index  $b_k$ , namely,  $c_i (i=1, 2, \dots, n)$ , and the corresponding single index matter-element to be reviewed is  $R_c$ , we can define the single index matter-element as,

$$R_c = (N_o, C, V_c) = \begin{bmatrix} N_o & c_1 & v_{c1} \\ & c_2 & v_{c2} \\ & \dots & \dots \\ & c_n & v_{cn} \end{bmatrix} \quad (8)$$

where  $N_o$  is the project to be reviewed;  $C$  is the whole characteristics of the comprehensive index  $b_k (k=1, 2, \dots, m)$  of  $N_o$ , namely, all the single indexes  $c_i (i=1, 2, \dots, n)$  of the comprehensive index  $b_k$  of  $N_o$ ;  $v_{ci}$  is the value of the single index  $c_i$ .

If there are  $m$  experts to review the project  $N_o$ ,  $v_{ci}$  being the comprehensive value of the single index  $c_i$  scored by the expert group,  $v_{ci}$  is defined as,

$$v_{ci} = \sum_{k=1}^m (v_{ik} \times z_k) \quad (9)$$

where  $v_{ik}$  is the value of single index  $c_i$  scored by the expert  $k$ ,  $z_k$  is the weight of expert  $k$  in the expert group.

If there are  $m$  comprehensive indexes in the project, namely,  $b_i (i=1, 2, \dots, m)$ , the comprehensive index matter-element  $R_b$  to be evaluated is defined as,

$$R_b = (N_o, B, V_b) = \begin{bmatrix} N_o & b_1 & v_{b1} \\ & b_2 & v_{b2} \\ & \dots & \dots \\ & b_m & v_{bm} \end{bmatrix} \quad (10)$$

where  $N_o$  is the project to be reviewed,  $B$  is the characteristics of  $N_o$ , namely, the comprehensive indexes of  $N_o$ ;  $v_{bk}$  is the value of the comprehensive index  $b_k (k=1, 2, \dots, m)$ . If the comprehensive index  $b_k$  is composed of single index  $c_i (i=1, 2, \dots, l)$ ,  $v_{bk}$  is defined as,

$$v_{bk} = \sqrt[l]{\prod_{i=1}^l v_{ci}} \quad (11)$$

Define the classical domain and section domain of the comprehensive index matter-element, according to the formula (2), (3). Then calculate the correlation of each comprehensive index for each grade of the review status.

After introducing the weight of comprehensive index, define the correlation of  $N_o$  for  $j$  grade of the review status as,

$$K_j(N_o) = \sum_{i=1}^n \omega_i K_j(b_i) \quad (12)$$

where  $n$  is the number of the comprehensive indexes,  $b_i(i=1, 2, \dots, n)$  is the  $i$ th comprehensive index,  $\omega_i$  is the weight of the comprehensive index  $b_i$ .

If  $\max(K_j(N_o))=K_{j_0}$ , we can conclude that the matter-element to be reviewed belongs to  $j_0$  grade.

If  $K_{j_0}(N_o)>1$ , it means that the matter-element to be evaluated exceeds the upper limit of the standard grade. The bigger its value is, the greater the potential for development is.

**3.3. Example analysis**

After the experts reviewing the science and technology fund project, the evaluation result will be returned. Take the evaluation result of the two project reviewed by the five experts selected above for example, shown as Table 2.

Table 2. Scoring conditions of engineering project A and B

Evaluation index		Fund project A					Fund project B				
		E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
b1	c1	0.9	0.8	0.9	0.9	0.8	0.8	0.8	0.7	0.8	0.9
	c2	1.0	1.0	0.8	1.0	1.0	0.6	0.8	0.8	1.0	0.8
	c3	0.8	1.0	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8
	c4	1.0	1.0	1.0	0.8	1.0	0.8	1.0	0.8	0.8	1.0
b2	c5	1.0	1.0	1.0	0.8	0.8	0.8	0.8	0.6	0.8	0.8
	c6	0.8	0.8	1.0	1.0	0.8	1.0	1.0	0.8	0.8	1.0
	c7	0.8	1.0	0.8	0.8	1.0	0.8	0.8	1.0	0.8	1.0
	c8	0.9	0.8	0.9	0.9	0.7	0.9	0.9	0.8	1.0	0.9
b3	c9	0.8	1.0	1.0	0.8	0.8	0.8	1.0	0.8	0.9	0.8
	c10	1.0	0.8	1.0	1.0	0.8	1.0	1.0	1.0	1.0	0.8

According to the scoring conditions of the fund project given by the five experts, considering the expert weight  $Z=\{z_1, z_2, z_3, z_4, z_5\}=\{0.186, 0.203, 0.204, 0.208, 0.199\}$ , we can define the corresponding comprehensive index  $R_{Ab}$  and  $R_{Bb}$  for project A and B by formula (8), (9), (10), (11) as,

$$R_{Ab} = \begin{bmatrix} N_{Ab} & b_1 & 0.913 \\ & b_2 & 0.909 \\ & b_3 & 0.88 \end{bmatrix}, \quad R_{Bb} = \begin{bmatrix} N_{Bb} & b_1 & 0.801 \\ & b_2 & 0.867 \\ & b_3 & 0.906 \end{bmatrix}$$

According to the formula (7), calculate the correlation of each comprehensive index of fund project A and B in each evaluation grade, the results are shown as Table 3 below.

Table 3. Correlation of comprehensive index of fund project A and B

index	Fund project A					Fund project B				
	excellent	good	medium	general	poor	excellent	good	medium	general	poor
b1	0.63	-0.42	-0.652	-0.751	-0.826	-0.198	0.49	-0.204	-0.431	-0.602
b2	0.59	-0.393	-0.636	-0.74	-0.818	0.17	-0.113	-0.468	-0.62	-0.734
b3	0.3	-0.2	-0.52	-0.657	-0.76	0.56	-0.373	-0.624	-0.731	-0.812

Determine the weight of the comprehensive index  $\{b_1, b_2, b_3\}$  of the project,  $\omega = \{0.5, 0.2, 0.3\}$ , calculate the comprehensive correlation of the fund project A and B, the results are shown as Table 4 below.

Table 4. Comprehensive Correlation of the Fund Project A and B

index	Fund project A					Fund project B				
	excellent	good	medium	general	poor	excellent	good	medium	general	poor
b	0.523	-0.349	-0.609	-0.721	-0.805	0.103	0.111	-0.383	-0.559	-0.691

We can see that the fund project A belongs to excellent grade and B belongs to good grade through the comprehensive correlation. Therefore, the fund project A superior to the fund project B, if select one from the two projects, we will select fund project A.

#### 4. Conclusion

The review work is a complex work which involves many aspects of factors in the engineering project. The final evaluation result is influenced directly according to the definition of various evaluation indexes and the corresponding weight. This paper is based on the matter-element analysis, considering fully the factors of the project itself and the review expert, establishing a comprehensive evaluation index system and comprehensive evaluation algorithm with fairness, operability.

As there are many complex factors on various project contents and expert personal factors and so on, we need to establish a series of corresponding indexes, which makes the establishment of the perfect engineering project evaluation index system still very difficult, pending further study and discussion.

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