Research on contract management evaluation of construction company based on fuzzy comprehensive evaluation model

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Received 28 October 2014, www.cmnt.lv

Abstract

Contract management is the core of project management of construction companies. Establishing a perfect contract management evaluation system of construction companies is of important significance to enhance their contract signing and performance as well as competitiveness in international market. Based on the overall contract management of construction companies, this paper discussed how to establish an evaluation system. Combined with fuzzy comprehensive evaluation, the established evaluation system was verified by an empirical analysis.

Keywords: contract management capability, evaluation model, fuzzy comprehensive evaluation, empirical analysis

1 Research significance

Contract management is the core of project management of construction companies and runs through the whole implementation of engineering project. It is of more significance to some large construction companies in China who attempt to step into the international market.

Contract management capability of project management personnel can be evaluated through some way, which enables us to become aware of shortcomings, differences and potential causes of low-efficient project implementation, and give early warnings.

2 Content of contract management of construction companies

Contract management of construction companies is the generic term of a series of legal behaviors on involved contract, including formation, performance, modification, dissolution, assignment, termination, review, supervision and control of contracts. Formation, performance, modification, dissolution, assignment, termination of contracts are the content of contract management, while the rest three are means of contract management [4].

Contract management of construction companies is the most complicated, painstaking and important work, which has significant impact on the whole engineering project.

3 Contract management evaluation model of construction companies

To evaluate contract management capability of China's construction companies, this paper deems that an evaluation model shall be established under the guidance of both domestic and foreign theories of contract management and combining with practical situations of China's construction companies as well as evaluation methods for project management.

3.1 LEVEL-1 EVALUATION INDEXES OF THE MODEL

Three level-1 evaluation indexes for contract management capability were concluded from review of existing associated research results.

1) Support of organizational system. Contract management is implemented through personnel, system and procedure set by the management organization of enterprises. The organizational management is important to contract management. The management organization of enterprises determines division of collaboration and function of departments, providing strong support to contract management.

2) Bidding and contracting management. Offer and commitment are two stages before the conclusion of contracts. Bidding is the offer of construction companies. The bid price not only can influence performance of enterprises directly, but also the key of winning the bidding. After winning the bidding, a "win-win" contract shall be signed by all means. These pave the way for contract performance.

3) Contract performance management. Contract performance is the core of whole contract management. Executives, project department, contract management department and other relevant departments are asked to perform contractual obligations in agreed time, cost and quality by all control means and win agreed rights. Since contract management is very complicated, it has high requirement on capabilities of related personnel.

The above three aspects are the key of the contract

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management capability evaluation model of construction companies (hereinafter referred as CMC model, Figure 1. They are level-1 evaluation indexes of the CMC model and the key domain indexes of contract management capability.

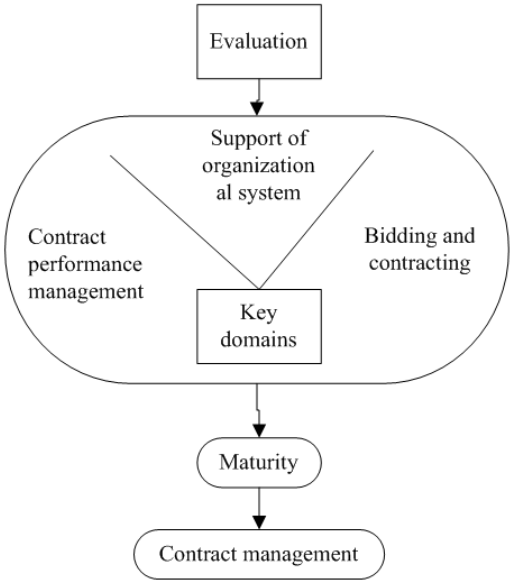

FIGURE 1 CMC model

3.2 LEVEL-2 EVALUATION INDEXES

OF THE MODEL

Due to the inadequate understanding of China's construction staff on contract management and their great differences of education background, opinions of relatively independent experts with rich experiences were used in this paper in order to establish a more scientific and reasonable evaluation system for engineering contract management. The experts mainly include scholars, enterprise managers and project managers in construction field. To get more comprehensive level-2 evaluation indexes, open-ended questionnaire survey was conducted. Firstly, experts were asked to list key indexes of three key domains through face-to-face interview or E-mail. After three questionnaire surveys, a total of 12 level-2 evaluation indexes were concluded under the assistance of experts. These indexes are, in accordance with the design principle of indexes, have certain scientific and independence and can reflect practical capabilities of key domains (Table 1).

3.3 WEIGHT DETEMINATION OF EVALUATION INDEXES

To reflect effect of evaluation indexes in the evaluation system, this paper analyzed significance of evaluation indexes through analytic hierarchy process (AHP). Based on experts' opinions and yaahp0.4.1 AHP software, weights of evaluation indexes were determined (Table 1).

TABLE 1 General situation of contract management evaluation indexes of the construction

goal	Level-1 indexes	Weight	Level-2 indexes	Weight	Maturity grades				
					Chaotic management	*Simple management*	*Standard management*	*Lean management*	*Strategic management*
Contract management capability (C)	Support of Organizational system (C_1.)	0.2972	Completeness of contract management system (C11)	0.2780	0/6	1/6	4/6	1/6	0/6
			Effectiveness of incentives(C_{12})	0.1361	0/6	1/6	3/6	2/6	0/6
			Adaptability of organizational structure (C_{13})	0.0875	0/6	1/6	3/6	2/6	0/6
			Competency of contract management personnel (C_{14})	0.4987	0/6	1/6	4/6	1/6	0/6
	Bidding and Contracting Management (C_2.)	0.1284	Bidding capacity (C_{21})	0.3522	0/6	0/6	3/6	3/6	0/6
			Contract risk management (C_{22})	0.3486	0/6	1/6	3/6	2/6	0/6
			Contract negotiation ability (C_{23})	0.2991	0/6	1/6	4/6	1/6	0/6
	Contract Performance Management (C_3)	0.5744	Contract claim management (C_{31})	0.3202	0/6	2/6	4/6	0/6	0/6
			Contract modification management (C_{32})	0.0584	0/6	0/6	3/6	2/6	1/6
			Contract cost, schedule and quality control (C_{33})	0.3856	0/6	2/6	3/6	1/6	0/6
			Contract analysis and presentation capability (C_{34})	0.0908	0/6	0/6	2/6	3/6	1/6
			Contract information management (C_{35})	0.1450	0/6	1/6	3/6	2/6	0/6

4 An empirical study about fuzzy evaluation on maturity of contract management capability of a construction company

4.1 DETERMINATION OF EVALUTION SET

Similar project management, maturity of contract management was also divided into five grades. Grade 1 represents the poorest contract management, while Grade 5 represents the highest contract management. Therefore, the grade evaluation set of contract management is:

C={chaotic management, simple management, standard management, lean management and strategic management}.

4.2 EVALUATION PREPARATION

4.2.1 Test Projects of the construction company

This paper tried to make a comprehensive evaluation on the contract management of the construction company through its projects under construction, finished projects, domestic and international projects, industrial construction project, civil construction projects and municipal construction projects. Its contract management capability was evaluated based on four domestic and foreign typical projects.

4.2.2 Composition of evaluation personnel

Evaluation personnel includes deputy manager and experts from headquarter, external experts, manager of UAE department, manager of project department, and manager of contract estimation department. The deputy manager from headquarter is the leader of this evaluation group.

4.3 WEIGHT DETERMINNATION OF EVALUATION INDEX

4.3.1 Build AHP structure

Social, economic and scientific management problems were analyzed by AHP. Firstly, problems shall be systematized and layered to build an AHP structure.

The established AHP structure built based on the index system of the CMC model is shown in Figure 2.

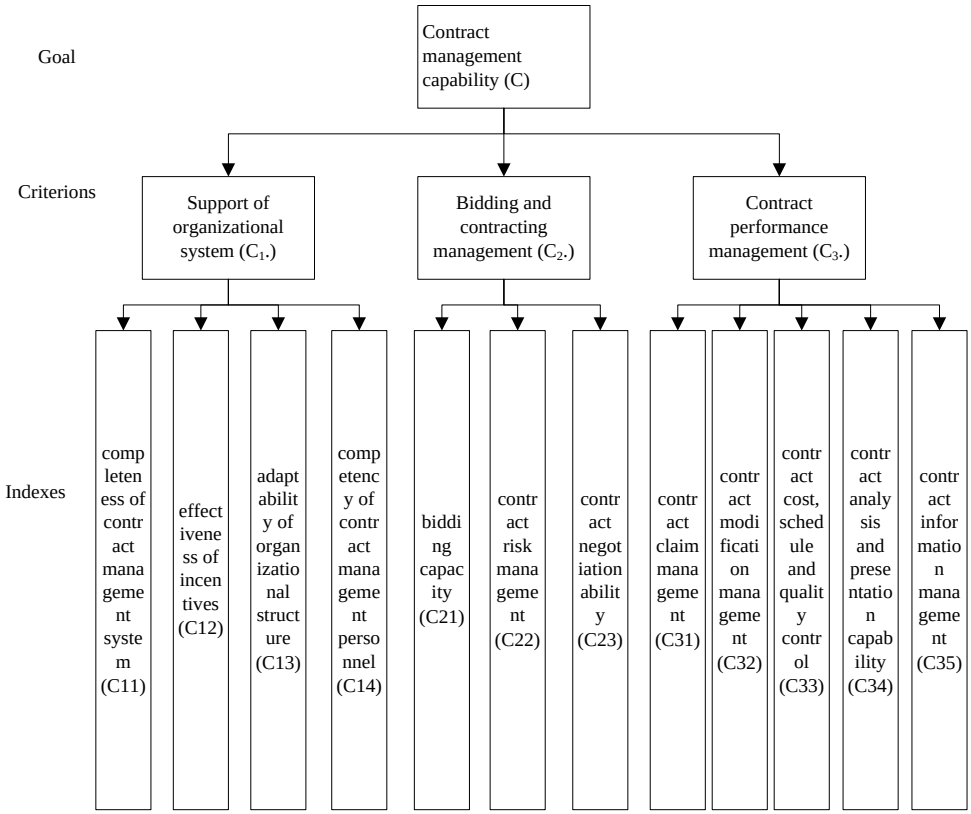

FIGURE 2 The level structure of contract management

4.3.2 Build judgment matrix

Suppose factors of previous layer (*C*) are criteria, which control factors of lower layer $(C_1, C_2, ...C_n)$. Our goal is to give weight of, $(C_1, C_2, ...C_n)$ according to their significance under the criterion Bk. For *n* factors, the judgment matrix of two factors is $C = (C_{ij})n*n$, where C_{ij} is the significance of *i* and *j* to the goal.
The built judgment matrix is:

	C_1	C_2	...	C_n
C_1	C_{11}	C_{12}	...	C_{1n}
C_2	C_{21}	C_{22}	...	C_{2n}
...	...	...	...	...
C_n	C_{n1}	C_{12}	...	C_{nn}

This judgment matrix is characteristic of:

1) $C_{ij} > 0$.

2) $C_{ij} = 1/C_{ji} (i \neq j)$.

3) $C_{ij} = 1 (i, j = 1, 2, ..., n)$.

Next, significance of C_i and C_j in criterion *C* was compared. "Significance" shall be given with certain numerical value, which uses 1-9 scale in this paper [25].

Then, evaluation personnel implemented the pairwise comparison of relevant factors by using their knowledge and experiences, filling in the weight evaluation table of contract management.

Weights of criteria are Criteria include Support of Organizational System, Bidding and Contracting Management as well as Contract Performance Management. Different evaluators got different judgment matrixes of criteria.

The judgment matrix of Evaluator 1 is:

	C_1	C_2	C_3
C_1	1	1/3	1/7
C_2	3	1	1/5
C_3	7	5	1

1) Calculate the product of each row of factors (M_i)

$$M_i = \prod C_{ij},\ i = 1, 2, ..., n,\ j = 1.$$

Therefore, $M = (0.0476, 0.6, 35)^T$.

2) Normalize $M_i (W_i)$

$$W_i = \sqrt[n]{M_i}.$$

Therefore, $W = (0.3625, 0.8434, 3.2711)^T$.

3) Normalize W_i

$$W_i = \frac{\overline{W_i}}{\sum_{j=1}^{n} \overline{W}_j}.$$

The eigenvector is: $W = (0.081, 0.1884, 0.7306)^T$.

4) Calculate the largest eigenvalue of the judgment matrix (λ_{max}). Therefore, $\lambda_{max} = 3.0649$.

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{3.0649 - 3}{3-1} = 0.0324.$$

5) Calculate the consistency ratio (CR): when $n = 3$, $RI = 0.58$.

$$CR = CI / RI = 0.0324 / 0.58 = 0.0559 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 2 is:

	C_1	C_2	C_3
C_1	1	5	1/5
C_2	1/3	1	1/9
C_3	5	9	1

Similarly, its eigenvectors can be calculated:

$$W = (0.1782, 0.0704, 0.7514)^T$$

$$\lambda_{max} = 3.0291, CI = 0.0145, RI = 0.58, CR = 0.0251 < 0.1$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 3 is:

	C_1	C_2	C_3
C_1	1	7	1/3
C_2	1/7	1	1/9
C_3	3	9	1

Its eigenvectors can be calculated:

$$W = (0.2897, 0.0549, 0.6554)^T$$

$$\lambda_{max} = 3.0803, CI = 0.0401, RI = 0.58, CR = 0.0692 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 4 is:

	C_1	C_2	C_3
C_1	1	3	1
C_2	1/3	1	1/5
C_3	1	5	1

Its eigenvectors can be calculated:

$$W = (0.4054, 0.1140, 0.4806)^T$$

$$\lambda_{max} = 3.0291, CI = 0.0145, RI = 0.58, CR = 0.0251 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 5 is:

	C_1	C_2	C_3
C_1	1	2	1
C_2	1/2	1	1/2
C_3	2	2	1

Its eigenvectors can be calculated:

$$W=(0.4,0.2,0.4)^T$$
$$\lambda_{\max}=3.0, CI=0, RI=0.58, CR=0<0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 6 is:

	C_1	C_2	C_3
C_1	1	3	1
C_2	1/3	1	1/3
C_3	1	3	1

Its eigenvectors can be calculated:

$$W=(0.4286,0.1429,0.4286)^T$$
$$\lambda_{\max}=3.0, CI=0, RI=0.58, CR=0<0.1$$

Therefore, this judgment matrix has satisfying consistency.

As a result, weights of three criteria are:

$$\begin{cases} a_1=(0.081+0.1782+0.2897+0.405+0.4+0.4286)/6=0.2971 \\ a_2=(0.1884+0.0704+0.0549+0.114+0.2+0.1429)/6=0.1284 \\ a_3=(0.7306+0.7514+0.6554+0.4806+0.4+0.4286)/6=0.5744 \end{cases}$$

The weight set of evaluation indexes is $C=(0.2971,0.1284,0.5744)$, representing the weights of Support of Organization System, Bidding and Contracting Management as well as Contract Performance Management, respectively.

Similarly, weight of the goal can be evaluated. Different evaluators got different judgment matrixes of Support of Organization System.

The judgment matrix of Evaluator 1 is:

	C_1	C_2	C_3	C_4
C_1	1	2	5	1/7
C_2	1/2	1	1	1/9
C_3	1/5	1	1	1/8
C_4	7	9	8	1

Then, its eigenvectors can be calculated:

$$W=(0.1628,0.0723,0.0592,0.7057)^T$$
$$\lambda_{\max}=4.2061, CI=0.0687, RI=0.90, CR=0.0763<0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 2 is:

	C_1	C_2	C_3	C_4
C_1	1	3	2	1/3
C_2	1/3	1	1/3	1/9
C_3	1/2	3	1	1/5
C_4	3	7	5	1

Then, its eigenvectors can be calculated:

$$W=(0.2186,0.0647,0.1349,0.5836)^T$$
$$\lambda_{\max}=4.0729, CI=0.0243, RI=0.90, CR=0.0270<0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 3 is:

	C_1	C_2	C_3	C_4
C_1	1	1	3	1/3
C_2	1	1	2	1/9
C_3	1/3	1/2	1	1/9
C_4	5	7	5	1

Then, its eigenvectors can be calculated:

$$W=(0.1421,0.1181,0.0596,0.6803)^T$$
$$\lambda_{\max}=4.0460, CI=0.0153, RI=0.90, CR=0.0171<0.1$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 4 is:

	C_1	C_2	C_3	C_4
C_1	1	5	7	1
C_2	1/5	1	4	1/5
C_3	1/7	1/4	1	1/7
C_4	1	5	7	1

Then, its eigenvectors can be calculated:

$$W=(0.4220,0.1097,0.0464,0.4220)^T$$
$$\lambda_{\max}=4.1398, CI=0.0466, RI=0.90, CR=0.0518<0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 5 is:

	C_1	C_2	C_3	C_4
C_1	1	1	3	1
C_2	1	1	5	1
C_3	1/3	1/5	1	1/7
C_4	1/3	1	3	1

Then, its eigenvectors can be calculated. Therefore, this judgment matrix has satisfying consistency. The judgment matrix of Evaluator 6 is:

	C_1	C_2	C_3	C_4
C_1	1	3	2	1/3
C_2	1/3	1	1	1/3
C_3	1/2	1	1	1/3
C_4	1	3	3	1

Then, its eigenvectors can be calculated:

$$W = (0.3468, 0.1279, 0.1416, 0.3838)^T$$
$$\lambda_{\max} = 4.0206, CI = 0.0069, RI = 0.90, CR = 0.0076 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.
As a result, weights of four indexes of Support of Organizational System are:

$$\begin{cases} a_{11} = (0.1628 + 0.2186 + 0.1421 + 0.4220.0.3754 + 0.3468)/6 = 0.2780 \\ a_{12} = (0.0723 + 0.0647 + 0.1181 + 0.1097 + 0.3241 + 0.1279)/6 = 0.1361 \\ a_{13} = (0.0592 + 0.1349 + 0.0596 + 0.0464 + 0.0834 + 0.1416)/6 = 0.0875 \\ a_{14} = (0.7057 + 0.5836 + 0.6803 + 0.4420 + 0.2168 + 0.3838)/6 = 0.4987 \end{cases}.$$

The weight set of Support of Organizational System is $A_1 = (0.2780, 0.1361, 0.0875, 0.4987)$, representing completeness of contract management system, effectiveness of incentives, adaptability of organizational structure and competency of contract management personnel, respectively.

Different evaluators got different judgment matrixes of Bidding and Contracting Management.

The judgment matrix of Evaluator 1 is:

	C_1	C_2	C_3
C_1	1	3	1/2
C_2	1/3	1	1/3
C_3	2	3	1

Then, its eigenvectors can be calculated:

$$W = (0.3325, 0.1396, 0.5278)^T$$
$$\lambda_{\max} = 3.0536, CI = 0.0268, RI = 0.58, CR = 0.0462 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 2 is:

	C_1	C_2	C_3
C_1	1	2	2
C_2	1/2	1	1
C_3	1/2	1	1

Then, its eigenvectors can be calculated:

$$W = (0.5, 0.25, 0.25)^T$$
$$\lambda_{\max} = 3.0, CI = 0, RI = 0.58, CR = 0 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 4 is:

	C_1	C_2	C_3
C_1	1	1	1
C_2	1	1	1
C_3	1	1	1

Then, its eigenvectors can be calculated:

$$W = (0.3333, 0.3333, 0.3333)^T$$
$$\lambda_{\max} = 3.0, CI = 0, RI = 0.58, CR = 0 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 5 is:

	C_1	C_2	C_3
C_1	1	3	5
C_2	1/3	1	2
C_3	1/5	1/2	1

Then, its eigenvectors can be calculated:

$$W = (0.6483, 0.2297, 0.1220)^T$$
$$\lambda_{\max} = 3.0037, CI = 0.00018, RI = 0.58, CR = 0.0032 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 6 is:

	C_1	C_2	C_3
C_1	1	1/5	1/3
C_2	5	1	1
C_3	1/5	1/2	1

Then, its eigenvectors can be calculated:

$$W = (0.1140, 0.4806, 0.4054)^T$$
$$\lambda_{\max} = 3.0291, CI = 0.0145, RI = 0.58, CR = 0.0251 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.
As a result,

$$\begin{cases} a_{11} = (0.3325 + 0.1852 + 0.5 + 0.3333 + 0.6483 + 0.1140)/6 = 0.3522 \\ a_{22} = (0.1396 + 0.6586 + 0.25 + 0.3333 + 0.2297 + 0.4806)/6 = 0.3486 \\ a_{23} = (0.5278 + 0.1562 + 0.25 + 0.3333 + 0.1220 + 0.4054)/6 = 0.2991 \end{cases}$$

The weight set of Bidding and Contract Management is $A_2 = (0.3522, 0.3486, 0.2991)$, representing bidding capacity, contract risk management and contract negotiation ability, respectively.

Different evaluators got different judgment matrixes of Contract Performance Management.

The judgment matrix of Evaluator 1 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	7	1/3	3	5
C_2	1/7	1	1/9	1/3	1
C_3	7	9	1	5	9
C_4	1/3	3	1/5	1	3
C_5	1/5	1	1/9	1/3	1

Then, its eigenvectors can be calculated:

$$W = (0.2609, 0.0449, 0.5304, 0.1157, 0.0480)^T$$

$$\lambda_{\max} = 5.0954, CI = 0.0239, RI = 1.12, CR = 0.0213 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 2 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	7	3	5	7
C_2	1/7	1	1/5	1/3	1/2
C_3	1/3	5	1	3	7
C_4	1/5	3	1/3	1	3
C_5	1/7	1	1/9	1/3	1

Then, its eigenvectors can be calculated:

$$W = (0.5009, 0.0537, 0.2460, 0.1292, 0.0703)^T$$

$$\lambda_{\max} = 5.4323, CI = 0.1081, RI = 1.12, CR = 0.0965 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 3 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	3	1/3	3	2
C_2	1/3	1	1/5	1/3	1/3
C_3	3	5	1	5	3
C_4	1/3	1	1/5	1	1/3
C_5	1/7	3	1/3	3	1

Then, its eigenvectors can be calculated:

$$W = (0.2235, 0.0729, 0.4613, 0.0729, 0.1694)^T$$

$$\lambda_{\max} = 5.1140, CI = 0.0285, RI = 1.12, CR = 0.0254 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 4 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	7	1	5	3
C_2	1/7	1	1/5	1	1/5
C_3	1	5	1	5	3
C_4	1/5	1	1/5	1	1/3
C_5	1/3	5	1/3	3	1

Then, its eigenvectors can be calculated:

$$W = (0.3734, 0.0524, 0.3491, 0.0621, 0.1630)^T$$

$$\lambda_{\max} = 5.12, CI = 0.0300, RI = 1.12, CR = 0.0268 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 5 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	8	1/2	5	2
C_2	1/8	1	1/9	1/3	1/4
C_3	2	9	1	7	3
C_4	1/5	3	1/7	1	1/2
C_5	1/2	4	1/3	3	1

Then, its eigenvectors can be calculated:

$$W = (0.2897, 0.0358, 0.4540, 0.0738, 0.1467)^T$$

$$\lambda_{\max} = 5.0797, CI = 0.0199, RI = 1.12, CR = 0.0178 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

The judgment matrix of Evaluator 6 is:

	C_1	C_2	C_3	C_4	C_5
C_1	1	3	1	3	1
C_2	1/3	1	1/3	1	1/3
C_3	1	3	1	3	1
C_4	1/3	1	1/3	1	1/3
C_5	1	3	1	3	1

Then, its eigenvectors can be calculated:

$$W = (0.2727, 0.0909, 0.2727, 0.0909, 0.2727)^T$$

$$\lambda_{\max} = 5.0, CI = 0, RI = 1.12, CR = 0 < 0.1.$$

Therefore, this judgment matrix has satisfying consistency.

As a result, weights of five indexes of Contract Performance Management are:

$$\begin{cases} a_{31} = (0.2609 + 0.5009 + 0.2235 + 0.3734 + 0.2897 + 0.2727)/6 = 0.3202 \\ a_{32} = (0.0449 + 0.0537 + 0.0729 + 0.0524 + 0.0358 + 0.0909)/6 = 0.0584 \\ a_{33} = (0.5304 + 0.2460 + 0.4613 + 0.3491 + 0.4540 + 0.2727)/6 = 0.3856 \\ a_{34} = (0.1157 + 0.1292 + 0.0729 + 0.0621 + 0.0738 + 0.0909)/6 = 0.0908 \\ a_{35} = (0.0480 + 0.0703 + 0.1694 + 0.1630 + 0.1467 + 0.2727)/6 = 0.0908 \end{cases}.$$

The weight set of Contract Performance Management is $A_3 = (0.3202, 0.0584, 0.3856, 0.0908, 0.1450)$, representing contract claim management, contract modification management, contract cost, schedule and quality control, contract analysis and presentation capability as well as contract information management, respectively.

4.4 FUZZY EVALUATION OF MATURITY

4.4.1 Fuzzy membership

The fuzzy memberships of level-2 indexes were evaluated by evaluators according to project situations (Table 1).

4.4.2 Fuzzy evaluation matrix

1. Fuzzy evaluation matrix of single factor.

According to Table 1, evaluation matrixes of single factor are:

Support of Organizational System:

$$R_1 = \begin{bmatrix} 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \end{bmatrix}.$$

Bidding and Contract Management:

$$R_2 = \begin{bmatrix} 0/6 & 0/6 & 3/6 & 3/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \end{bmatrix}.$$

Contract Performance Management:

$$R_3 = \begin{bmatrix} 0/6 & 2/6 & 4/6 & 0/6 & 0/6 \\ 0/6 & 0/6 & 3/6 & 2/6 & 1/6 \\ 0/6 & 2/6 & 3/6 & 1/6 & 0/6 \\ 0/6 & 0/6 & 2/6 & 3/6 & 1/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \end{bmatrix}.$$

Then, the judgment vectors of Support of Organizational System (B_1), Bidding and Contract Management (B_2) as well as Contract Performance Management (B_3) can be calculated from $B = A_i * R_i$:

$$B_1 = (0.2780, 0.1361, 0.0875, 0.4987) * \begin{bmatrix} 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \end{bmatrix} = (0, 0.1667, 0.6296, 0.204, 0),$$

$$B_2 = (0.3522, 0.3486, 0.2991) * \begin{bmatrix} 0/6 & 0/6 & 3/6 & 3/6 & 0/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \\ 0/6 & 1/6 & 4/6 & 1/6 & 0/6 \end{bmatrix} = (1080, 0.5498, 0.3422, 0),$$

$$B_3 = (0.3202, 0.0584, 0.3856, 0.0908, 0.1450) * \begin{bmatrix} 0/6 & 2/6 & 4/6 & 0/6 & 0/6 \\ 0/6 & 0/6 & 3/6 & 2/6 & 1/6 \\ 0/6 & 2/6 & 3/6 & 1/6 & 0/6 \\ 0/6 & 0/6 & 2/6 & 3/6 & 1/6 \\ 0/6 & 1/6 & 3/6 & 2/6 & 0/6 \end{bmatrix} = (0, 0.2594, 0.5382, 0.1775, 0.0249).$$

2. The judgment matrix of multiple factors is:

$$B = (0.2971, 0.1284, 0.5744) * \begin{bmatrix} 0 & 0.1667 & 0.6296 & 0.2040 & 0 \\ 0 & 0.1080 & 0.5498 & 0.3422 & 0 \\ 0 & 0.2594 & 0.5382 & 0.1775 & 0.0249 \end{bmatrix} = (0, 0.2124, 0.5668, 0.2065, 0.0143).$$

4.4.3 Evaluation on the maturity of contract management

Evaluation set for the maturity of contract management is $C = (C_1, C_2, C_3) =$ (Support of Organizational System, Bidding and Contract Management, Contract Performance Management). The evaluation standard is divided into five grades: $U(1, 2, 3, 4, 5)$, representing chaotic management, simple management, standard management, lean management and strategic management, respectively.

1. Single factor evaluation

$$C_1 = B_1 * U^T = (0, 0.1667, 0.6296, 0.204, 0) * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{vmatrix} = 3.0382.$$

This indicates that the maturity of Support of Organizational System is 3.0382, close to standard management. The construction company shall enhance support of organizational system.

$$C_2 = B_2 * U^T = (0, 0.1080, 0.5498, 0.3422, 0) * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{vmatrix} = 3.2342.$$

This reveals that the maturity of Bidding and Contract Management is 3.2342, between standard and lean management, close to standard management. The construction company still shall enhance its bidding and contract management.

$$C_3 = B_3 * U^T = (0, 0.2594, 0.5382, 0.1775, 0.0249) * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{vmatrix} = 2.9679 \cdot$$

This demonstrates that the maturity of Contract Performance Management is 2.9679, between simple and standard management, close to standard management. The construction company shall further standardize implementation of contract management and improve contract performance management continuously.

2. Multi-factor evaluation

$$C = B * U^T = (0, 0.2124, 0.5668, 0.2065, 0.0143) * \begin{vmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{vmatrix} = 3.0227 .$$

This shows that the maturity of contract management capability is 3.0227, close to standard management. The construction company has basically achieved effective contract management and control, but still has to further improve its contract management capability.

5 Conclusions

The evaluation group attempts to make a comprehensive evaluation on the contract management of the construction company through its projects under construction, finished projects, domestic and international projects, industrial construction project, civil construction projects and municipal construction projects. The evaluation reflects that the construction company has standard contract management, far from the lean management. If it wants to get an invincible position in international competition and win more economic benefits, the contract management capability still needs further improvement. Its maturity of Bidding and Contract Management is the highest, while that of Contract Performance Management is the lowest. However, both of them are close to standard management.

Acknowledgements

Project Name: Hebei Construction Technology Research Program in 2012, Project Number: 2012-2031

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