Research on Risk Evaluation of Whole Process Cost Consulting Service Based on Set Value Method

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ABSTRACT
Carrying out the whole process of cost consulting services may face risks such as long business cycle and many uncontrollable factors. If these risk factors cannot be effectively identified and prevented, it will not only bring serious economic losses to the owner, but also affect the market reputation of engineering cost consulting enterprises, which is not conducive to the improvement of the market competitiveness of engineering cost consulting enterprises. Therefore, this paper studies the related risks when engineering cost consulting enterprises carry out the whole process cost consulting, first identifies the risk list of the whole process cost consulting service, constructs the risk evaluation model, uses the set-valued method to evaluate the risk of the whole process cost consulting, and finally makes an empirical analysis.

Keywords: *Whole process cost, project consultancy, Risk Assessment, Set-valued method*

1. INTRODUCTION

According to data from the Ministry of Housing and Urban-Rural Development, our country's engineering cost consulting business revenue has continued to grow. At the end of 2020, engineering cost consulting companies had 790,604 employees, an increase of 34.8% over the previous year [4]. The operating income of engineering cost consulting companies was 2570.64 billion yuan, an increase of 40.0% over the previous year [5].

The whole process cost management refers to the whole process and dynamic cost management of accepting entrustment and undertaking construction projects. The whole process cost has more important characteristics than the traditional cost consultation in terms of professionalism, independence and comprehensiveness. In terms of specialty, engineering and consulting companies have special knowledge and experience in the field of design, and the level of specialization can improve the quality of the whole consultation [1].

Due to the large amount of bids involved in the whole process cost consultation, long consultation cycle and many uncertain factors, the cost consultation unit will face various risks when accepting the whole process cost consultation business. In order to successfully complete the whole process cost consulting business and achieve its strategic goal of sustainable development, cost consulting units need to effectively prevent the risks of the whole process cost consulting business, minimize the influencing factors of risks at each stage, and improve the ability to resist risks.

2. WHOLE PROCESS COST CONSULTING RISK INDICATORS

At present, the identification methods of evaluation index include deduction method, induction method, transplantation method, etc., but these evaluation index identification methods are all derived from the most basic literature research and practice investigation methods [2]. The former can sort and summarize the latest research results to determine the research direction, latest research results and research deficiencies of this topic [3]. However, in view of the differences in research topics between papers and related literature, the fit of the evaluation indicators obtained from literature research is not very ideal. Therefore, it can be supplemented and corrected by other methods.

By sorting out and analyzing the retrieved literature, it is found that most of the literatures that directly study the risk indicators of the whole process of cost consulting are classified and designed according to the whole

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process of the project, and a few have designed the evaluation index system from the enterprise level and the project level as the dimensions. The specific risk factors basically include all the cost consulting work from the entire investment decision-making stage to the project completion and acceptance stage. In addition, some literatures have carried out evaluation index research from the basis of work, organizational structure, outcome documents and archives. Part of the literature analyzes risks from the whole process of cost consulting at different stages, and also studies cost consulting risks from different project participants such as construction units, cost consulting, and construction units.

The risk evaluation index based on the whole process cost consulting of engineering consulting enterprises is not comprehensive and systematic, and the conclusions obtained from direct research in the literature need to be consistent with engineering practice. The thesis interviewed 13 senior staff who have been engaged in the whole process cost management for a long time. The whole-process cost risks obtained from the literature analysis and expert interviews are sorted out, and the overlapping risks are merged or deleted, and finally the risk indicators shown in Table 1 are formed. The whole process cost consulting risk evaluation index system includes two aspects: external risk and internal risk.

Table 1: The whole process cost risk evaluation index.

Risk Assessment Dimensions		Risk Evaluation Index	Risk Assessment Dimensions		Risk Evaluation Index
External risk	Owner's Risk	Owner's violation of laws and regulations leads to additional claims and the risk of out-of-control investment	Insider risk	Risks in project contracting	Information asymmetry
		The risk of interference from the owner's site management department			Inadequate on-site research
		The blind command of the owner's personnel leads to the risk of increased costs			Risks of lax contract review
		Risk of refusal or delay in payment of consulting fees		Risks in project preparation	Project team formation and team management
		Owner's inability to provide information or other supporting risks			Unfamiliar with project technology and technology
		Risk of unreasonable demands made by the owner other than the contract			Risk of professional competence of project members
	Contractor Risk	Illegal operations			Unreasonable risk of project consulting plan
		Risk of collusive interference with the owner		Risks in project implementation	Project personnel offside risk
		Malicious or passive cooperation			Unreasonable division of labor among project members
	Survey and Design Risk	Risk of inaccurate survey and design			The formalized implementation of the three-level review system is not in place
		Risk of insufficient depth of design drawings			Unable to strictly implement the project cost business standards and specifications

		Malicious or passive cooperation			Project data file management and handover are not standardized
	Project supervision risk	Risk of dereliction of duty in project supervision			Formalized risk of internal project assessment
		The interface with the project supervision work is not handled properly			The implementation of the authorization system is not in place, resulting in the inability of the project business to execute
		Risk of collusive interference with the owner			Unable to respond to owners' rationalization requests
		Malicious or passive cooperation			No reasonable revision to target cost
	Force Majeure Risk	Natural disaster risks lead to project delays or increased costs		Project termination risk	Unable to unify and complete the archive as required
		Risk of government bans leading to project delays or increased costs			Project review is not in place
					Failure to provide cost database construction and other follow-up to the owner as required

3. RISK EVALUATION METHOD OF WHOLE PROCESS COST CONSULTATION

Compared with the commonly used fuzzy comprehensive evaluation methods, the set-valued statistical method can accurately estimate the risk probability results, rather than simply giving the probability grade of the risk evaluation index, which can improve the accuracy of the risk probability results. Therefore, the paper uses the set-valued method to evaluate the risk of the whole process of cost consultation. The whole process cost risk consequence loss is transformed into the relative weight of the risk evaluation index. The overall risk of the whole process cost is a unit, and then the relative importance of each risk factor to the risk system is obtained by calculating the risk factor weight, which is regarded as the relative consequence loss to the overall risk. According to the definition of risk, the set-valued statistical method and weight calculation are used to calculate the risk probability and consequence loss respectively, and then the harmfulness of each risk factor is calculated, and the risks are sorted according to the degree of harmfulness to determine the key risks.

3.1 Probability of risk occurrence

(1) Risk probability standard

Similar to fuzzy comprehensive evaluation, using set-valued statistical method to estimate the risk probability also needs to first clarify the risk probability interval grade standard, set up a reasonable comment set, and then realize the risk probability estimation of metallurgical machinery procurement. The set-valued statistical method usually adopts the five grade risk probability estimation standards shown in Table 2, and the risk probability value is continuously increased according to the increase of risk probability.

Table 2: Risk Scoring Criteria

Risk probability range（%）	explanation
0-10	almost never
11-30	very unlikely
31-60	possible
61-90	Probably
90-100	very possible

(2) Risk probability estimation

Assuming that the number of personnel involved in the risk assessment is L, and the given risk probability interval of the Kth position is $[P_1^K, P_2^K]$, which represent the minimum and maximum possible risk probability, respectively, the occurrence probability result of this risk assessment index is : $[P_1^1, P_2^1]$, $[P_1^2, P_2^2]$, …$[P_1^l, P_2^l]$. The set of risk probabilities is formed into a numerical axis frequency distribution, and the use of falling shadows to represent the frequency of a certain area being covered is as follows:

$$\bar{X}(P) = \frac{1}{L}\sum_{K=1}^{L} X_{[P_1^L, P_2^L]}(P) \quad (1)$$

$$X_{[P_1^L, P_2^L]}(P) = \begin{cases} 1, & P_1^K \le P \le P_2^K \\ 0, & \text{else} \end{cases} \quad (2)$$

$\bar{X}(P)$ is zy Coverage Frequency, $X_{[P_1^k, P_2^k]}$ is ling shadow function for P-values. The probability of occurrence of the risk assessment index is calculated according to the following formula.

$$\bar{P} = \frac{\int_{P_{max}}^{P_{min}} P\bar{X}(P)d_p}{\int_{P_{max}}^{P_{min}} \bar{X}(P)d_p} \quad (3)$$

$$\int_{P_{max}}^{P_{min}} \bar{X}(P)d_p = \frac{\sum_{K=1}^{L}\left(P_2^K\right)^2 - \left(P_1^K\right)^2}{2L} \quad (4)$$

$$\int_{P_{max}}^{P_{min}} P\bar{X}(P)d_p = \frac{\sum_{K=1}^{L} P_2^K - P_1^K}{L} \quad (5)$$

$$\bar{P} = \frac{\sum_{K=1}^{L}\left(P_2^K\right)^2 - \left(P_1^K\right)^2}{2\sum_{K=1}^{L} P_2^K - P_1^K} \quad (6)$$

(3) Credibility evaluation

There are certain differences in the understanding of a certain evaluation index by different evaluators, so there may be certain differences in the risk evaluation results. However, if most evaluators can centrally identify the risk probability in a certain interval, it is likely to indicate that the risk probability result has high credibility. The degree of scattering of the incident shadow within the frequency coverage of the assumed probability of occurrence of the risk factor is denoted as g. It is believed that b is less than 0.1.

$$g = \frac{\sum_{k=1}^{n}\left(P_2^K - \bar{p}\right)^3 - \left(P_1^K - \bar{p}\right)^3}{3\sum_{K=1}^{L} P_2^K - P_1^K} \quad (7)$$

$$b = \frac{1}{1+g} \quad (8)$$

3.2 Estimation of Risk Consequence Loss

The consequence loss of risk factors can be transformed into the problem of relative weight. Combing the literature, it is found that the weight determination methods mainly focus on direct weight method, analytic hierarchy process, order relationship analysis method, entropy method and so on. Combined with the qualitative characteristics of the risk factors in the whole process of cost consultation constructed in this paper, we should adopt the subjective weighting method. In view of the lack of subjectivity of the weighting results, we can increase the number of participating experts to eliminate it.

(1) Establish hierarchical structure model

Arrange decision goals, factors, and options in a hierarchical structure according to their interrelationships. The target layer is the whole process cost risk. The middle layer includes the owner's risk, the contractor's risk, the survey and design risk, the engineering supervision risk and the force majeure risk of the external risk, and the risk of the project contracting link, the project preparation link risk, the project implementation link risk and the project termination link risk of the internal risk. Specific risk factors are at the program level.

(2) Constructing the judgment matrix

In the criterion layer, a judgment matrix is constructed for the factors belonging to the same level that belong to the upper-level factors. The meaning of the judgment matrix importance scale is shown in Table 3.

Table 3: significance scale meaning of judgment matrix

Comparison of two factors	Quantized value
Equally important	1
Slightly important	3
Strong and important	5
Strongly important	7
Extremely important	9
Intermediate value of two adjacent judgments	2，4，6，8

(3) Calculate the weight vector and check the consistency

Let the judgment matrix be: $B=\{b_1, b_2,\ldots,b_n\}$,the eigenvector: $W=\{w_1,w_2,\ldots,w_n\}$, the largest eigenvalue λ_{max}, then the relationship between the three is:

$$BW = \lambda_{max}W \quad (9)$$

The calculation of the consistency test index shown in formula 10. m is the order of judgment matrix.

$$CI = \frac{\lambda_{max} - m}{m-1} \quad (10)$$

The calculation of the consistency test index *RI* is shown in formula 11, and the *RI* value can be obtained by looking up the table.

$$CR = \frac{CI}{RI} \tag{11}$$

Judgment conditions: CR<0.10, meet the consistency requirements; CR>0.10, do not meet the consistency, reconstruct the judgment matrix.

3.3 Harmful degree of cost risk in the whole process

Calculate the risk hazard degree of the whole process cost according to the risk definition, see Equation 12.

$$R = \sum_{i=1}^{n} \overline{P}_i \cdot w_i \tag{12}$$

R refers to the result of hazard degree of cost risk in the whole process. $\overline{P}_i$ represents the risk probability of the whole process cost. W_i indicates the consequence of cost risk loss in the whole process. According to the risk definition, the whole process cost risk can be comprehensively evaluated on the basis of determining the risk probability and risk loss, and the hazard degree of the whole process cost risk can be calculated. In addition, various risk evaluation indicators can be sorted according to the comprehensive evaluation results, so as to determine the main risk, secondary risk and general risk, and carry out risk prevention for different types of risks.

4. EMPIRICAL ANALYSIS

Taking the whole process engineering cost consultation of an industrial park project as an example, this paper evaluates the whole process cost service risk and the main key risk factors. Five experts with rich experience in project cost management or professional research foundation were selected to participate in this empirical analysis. The experts involved in risk assessment have at least 10 years of working experience, and have the title of senior engineer or above, and are very familiar with the whole process of cost risk management. In addition, it is agreed that 5 evaluators have equal rights in the risk evaluation process and can conduct this risk evaluation fairly and justly.

4.1 Risk probability estimation

Collect case project risk data and information to provide a basis for risk assessment. According to the risk characteristics of the case project, combined with the whole process cost risk factors selected in the paper, the set value statistical method is used to estimate the risk probability of metallurgical machinery procurement. Taking "the owner's violation of laws and regulations leads to the increase of additional claims and the risk of out-of-control investment" as an example, the risk probability estimation results given by experts are shown in Table 4.

Table 4: Scoring result

expert	1	2	3	4	5
probability	[43,45]	[43,51]	[42,50]	[43,49]	[48,51]

$P=[(45^2-43^2)+(51^2-43^2)+(50^2-42^2)+(49^2-43^2)+(51^2-48^2)]\div\{2\times[(45-43)+(51-43)+(50-42)+(49-43)+(51-48)]\}=47$

$g=[(45^3-43^3)+(51^3-43^3)+(50^3-42^3)+(49^3-43^3)+(51^3-48^3)]\div\{3\times[(45-43)+(51-43)+(50-42)+(49-43)+(51-48)]\}=2171.$

$b=1\div(1+2170)=0.001<0.1.$

Similarly, the probability estimation and credibility evaluation of other risks are shown in Table 5.

Table 5: Risk probability estimation and reliability evaluation table

Evaluation indicators and weights	expert 1	expert 2	expert 3	expert 4	expert 5	Probability (%)	b
Owner's violation of laws and regulations leads to additional claims and the risk of out-of-control investment	[43,45]	[43,51]	[42,50]	[43,49]	[48,51]	47	0.001
The risk of interference from the owner's site management department	[69,72]	[78,80]	[73,75]	[73,77]	[79,81]	75	0.000
The blind command of the owner's personnel leads to the risk of increased costs	[33,37]	[39,41]	[36,39]	[37,41]	[33,35]	37	0.001
Risk of refusal or delay in payment of consulting fees	[12,16]	[13,15]	[15,20]	[12,16]	[11,16]	15	0.005

Owner's inability to provide information or other supporting risks	[13,19]	[14,19]	[13,19]	[12,15]	[13,18]	16	0.004
Risk of unreasonable demands made by the owner other than the contract	[31,37]	[32,34]	[33,36]	[26,30]	[22,30]	30	0.001
Illegal operations	[41,46]	[47,51]	[46,52]	[41,48]	[49,52]	47	0.000
Risk of collusive interference with the owner	[21,25]	[24,28]	[17,19]	[18,21]	[14,17]	21	0.002
Malicious or passive cooperation	[21,26]	[20,24]	[23,25]	[22,27]	[23,27]	24	0.002
Risk of inaccurate survey and design	[53,56]	[51,53]	[48,53]	[58,59]	[63,66]	55	0.000
Risk of insufficient depth of design drawings	[34,39]	[33,38]	[36,41]	[33,43]	[34,42]	37	0.001
Malicious or passive cooperation	[15,22]	[10,18]	[14,19]	[15,20]	[13,19]	16	0.004
Risk of dereliction of duty in project supervision	[15,19]	[17,21]	[17,19]	[18,19]	[13,20]	17	0.003
The interface with the project supervision work is not handled properly	[17,21]	[18,21]	[16,19]	[15,13]	[14,20]	18	0.003
Risk of collusive interference with the owner	[31,33]	[29,30]	[18,23]	[46,47]	[27,30]	27	0.001
Malicious or passive cooperation	[17,23]	[19,22]	[10,11]	[14,16]	[17,18]	18	0.003
Natural disaster risks lead to project delays or increased costs	[21,26]	[20,24]	[23,25]	[22,27]	[23,27]	24	0.002
Risk of government bans leading to project delays or increased costs	[19,22]	[20,24]	[21,25]	[20,26]	[23,24]	22	0.002
information asymmetry	[21,25]	[24,28]	[17,19]	[18,21]	[14,17]	21	0.002
Inadequate on-site research	[33,37]	[39,41]	[36,39]	[37,41]	[33,35]	37	0.001
Risks of lax contract review	[27,30]	[31,33]	[17,22]	[16,19]	[27,28]	23	0.002
Project team formation and team management	[12,16]	[13,15]	[15,20]	[12,16]	[11,16]	15	0.005
Unfamiliar with project technology and technology	[21,23]	[7,10]	[8,10]	[13,16]	[21,22]	14	0.004
Risk of professional competence of project members	[17,25]	[16,20]	[13,19]	[18,23]	[17,20]	19	0.003
Unreasonable risk of project consulting plan	[43,45]	[43,51]	[42,50]	[43,49]	[48,51]	47	0.000
Project personnel offside risk	[29,30]	[26,28]	[25,28]	[36,38]	[31,33]	30	0.001
Unreasonable division of labor among project members	[21,26]	[18,21]	[16,24]	[18,20]	[19,20]	21	0.002
The formalized implementation of the three-level review system is not in place	[36,40]	[51,53]	[42,47]	[50,56]	[53,59]	49	0.000
Unable to strictly implement the project cost business standards and specifications	[19,23]	[17,26]	[11,15]	[19,24]	[17,23]	20	0.002
Project data file management and handover are not standardized	[23,30]	[24,30]	[23,27]	[20,30]	[21,28]	26	0.002
Formalized risk of internal project assessment	[20,24]	[13,15]	[9,12]	[13,18]	[16,20]	17	0.003

The implementation of the authorization system is not in place, resulting in the inability of the project business to execute	[21,25]	[24,28]	[17,19]	[18,21]	[14,17]	21	0.002
Unable to respond to owners' rationalization requests	[15,19]	[17,21]	[17,19]	[18,19]	[13,20]	17	0.003
No reasonable revision to target cost	[31,32]	[19,23]	[24,26]	[28,30]	[13,19]	21	0.002
Project review is not in place	[31,32]	[19,23]	[24,26]	[28,30]	[13,19]	21	0.002
Unable to unify and complete the archive as required	[10,14]	[13,17]	[9,10]	[11,13]	[8,10]	12	0.006
Failure to provide cost database construction and other follow-up to the owner as required	[21,23]	[7,10]	[8,10]	[13,16]	[21,22]	14	0.004

4.2 Calculation of Risk Loss and Hazard Degree of the Whole Process Cost

Issue a questionnaire about the importance of the whole process cost risk index to obtain a judgment matrix, take the average value to establish the importance judgment matrix of the whole process cost consulting risk index, calculate the weight of the mean value and conduct a consistency test, if it fails the consistency test Then, the judgment matrices in each questionnaire are checked for consistency one by one, and the unqualified judgment matrices are eliminated and recalculated until the consistency is satisfied. Table 6 shows the loss degree (weight) of the risk factor consequences of the whole process cost consultation.

According to the definition of risk, combined with the calculated risk probability and risk consequence loss, the hazard degree of the whole process cost risk is calculated. The degree of risk hazard is normalized, and the percentage and cumulative percentage of the hazard degree of each risk factor are calculated, as shown in Table 6. The results show that the biggest risk is the unreasonable risk of the project consulting plan, with risk hazards accounting for 10.40%, followed by the risk of inaccurate survey and design, accounting for 7.73%, the risk of interference by the owner's on-site management department, illegal operations, and a three-level review system The risk of formal implementation is not in place, the risk of project delay or cost increase caused by government ban risk, the risk of colluding with the owner and the risk of interference, the risk of insufficient depth of design drawings, and the risk of natural disaster risk leading to project delay or cost increase risk. The cumulative risk accounts for 55.36%, which is the main risk of this case project.

Table 6: Calculation results of the weights of the risk evaluation indicators for the whole process of cost consulting.

Risk Indicator	Probability	Consequential loss	harmfulness	percentage	Cumulative percentage
Risk of unreasonable project consultation scheme	47.00%	0.5728	0.2692	10.40%	10.40%
Risk of inaccurate survey and design	55.00%	0.3638	0.2001	7.73%	18.13%
Interference risk of the owner's site management department	75.00%	0.2368	0.1776	6.86%	25.00%
Illegal operation	47.00%	0.3774	0.1774	6.85%	31.85%
Risk of inadequate formalization of the three-level review system	49.00%	0.2928	0.1435	5.54%	37.40%
Risk of project delay or cost increase caused by government ban	22.00%	0.5531	0.1217	4.70%	42.10%

Risk of interference in collusion with the owner	27.00%	0.4481	0.121	4.68%	46.77%
Risk of insufficient depth of design drawings	37.00%	0.3107	0.115	4.44%	51.22%
Risk of project delay or cost increase caused by natural disaster risk	24.00%	0.4469	0.1073	4.15%	55.36%
Risk of malicious or negative cooperation of the contractor	24.00%	0.3785	0.0908	3.51%	58.87%
Risk of insufficient on-site investigation	37.00%	0.2441	0.0903	3.49%	62.36%
Risk of lax contract review	23.00%	0.3785	0.0871	3.37%	65.73%
Risk of inadequate project review	21.00%	0.4044	0.0849	3.28%	69.01%
Risk of information asymmetry	21.00%	0.3774	0.0793	3.06%	72.07%
Risk of cost increase due to blind command of the owner's personnel	37.00%	0.2057	0.0761	2.94%	75.01%
The owner's violation of laws and regulations leads to the increase of additional claims and the risk of out of control investment	47.00%	0.1515	0.0712	2.75%	77.76%
Risk of malicious or negative cooperation in survey and design	16.00%	0.3255	0.0521	2.01%	79.78%
Risk of interference in collusion with the owner	21.00%	0.2441	0.0513	1.98%	81.76%
Other unreasonable requirements and risks beyond the contract proposed by the owner	30.00%	0.1531	0.0459	1.77%	83.53%
Risk of malicious or negative cooperation of engineering supervision	18.00%	0.2331	0.042	1.62%	85.15%
Risk of failure to file and sort out uniformly and completely as required	12.00%	0.3443	0.0413	1.60%	86.75%
Unable to provide cost database construction and other follow-up services to the owner as required	14.00%	0.2513	0.0352	1.36%	88.11%
Risk of dereliction of duty in engineering supervision	17.00%	0.1887	0.0321	1.24%	89.35%
Risk of unfamiliarity with project process and technology	14.00%	0.2196	0.0307	1.19%	90.54%
Risk of nonstandard management and handover of project data and Archives	26.00%	0.1156	0.0301	1.16%	91.70%
Formal risk of internal assessment of the project	17.00%	0.1495	0.0254	0.98%	92.68%
The owner is unable to provide information or other support risks	16.00%	0.1534	0.0245	0.95%	93.63%
Risk of inadequate handling of work interface with project supervision	18.00%	0.1301	0.0234	0.90%	94.53%
Risk of failure to respond to rationalization requirements put forward by the owner	17.00%	0.1203	0.0205	0.79%	95.32%
Project team formation and team management risk	15.00%	0.1216	0.0182	0.70%	96.03%

Risk of failing to strictly implement the project cost business standards	20.00%	0.0839	0.0168	0.65%	96.68%
Professional competence risk of project members	19.00%	0.086	0.0163	0.63%	97.31%
Offside risk of project personnel	30.00%	0.0539	0.0162	0.63%	97.93%
There is no risk of reasonable revision of the target cost	21.00%	0.0763	0.016	0.62%	98.55%
Risk of refusing or delaying the payment of consulting fees	15.00%	0.0995	0.0149	0.58%	99.13%
Failure to implement the authorization system leads to the risk that the project business cannot be implemented	21.00%	0.0656	0.0138	0.53%	99.66%
Risk of unreasonable division of labor among project members	21.00%	0.0421	0.0088	0.34%	100.00%

5. CONCLUSIONS

The paper identifies the risk factors of the whole process cost consulting service, constructs a risk evaluation model based on AHP and Statistical Analysis of Set Values, and conducts an empirical analysis. The results show that the engineering consulting unit can find the main risks through risk assessment, and control them accordingly, and then reduce the service risk.

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