Electric Power Project Risk Evaluation Analysis in Grey Level Vague CIM Model

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***Abstract*—In order to solve the contents of electric project risk factors that are numerous, random, multiple in structure layer, evaluation vague and difficult in quantization, the paper combines CIM model and AHP method and apply them into the electric power project risk evaluation, puts forward the establishment of grey vague CIM model based two-level risk index membership function and demonstrates the feasibility and correctness of this model by examples. Results prove that this model has great feasibility and reliability and provide a very good method of decision making for the evaluation of electric power project risk.**

Keywords- electric power project; risk evaluation; grey vague; CIM model

I. INTRODUCTION

Electric power industry is the important foundation of the domestic economy, which burdens the important responsibility of supporting domestic economic development and ensuring the electrical needs of daily life. For the continuous increase of domestic electric power projects and the increasing investment amount of this kind of project, the construction of most electrical projects in our country adopts the mode of project financing. For the characteristics of electric power projects are long construction period, long financing period, large scale, complex technologies, multiple touching units, the risk of electric engineering projects is greater compared to other construction projects, which directly relates to whether the project financing can be successful and whether projects can be under construction. Therefore, researches on the evaluation on electric power project financing risk is of great realistic importance for effectively utilizing each kind of funds, successfully implementing the project construction and protecting the benefits of investors. For risk factors of electric power projects have characteristics of large quantity, randomness, multiple structure layers, vague evaluation, difficult quantization and etc, the quantitative treatment of risk factors of project financing risk need considering. The paper combines layer analysis method, puts forward grey vague CIM model and applies into the quantitative evaluation of some electric power project financing risk, which provides more objective and correct risk evaluation evidence for financing decision-making of projects.

II. THE ESTABLISHMENT OF ELECTRIC POWER PROJECT RISK EVALUATION INDEX SYSTEM

In accordance with principles of the combination of comprehensiveness, systematicness, comparability, scientificity, operability, utility and advancement followed by the construction of risk index evaluation system [3]，with the combination of the developing situation of domestic and foreign electric power project evaluation index system researches as well as ordinary risks encountered in the financing practice of electric power projects [4-5]，the risk evaluation index system shown in Figure 1 has been built with the use of layer analysis principle:

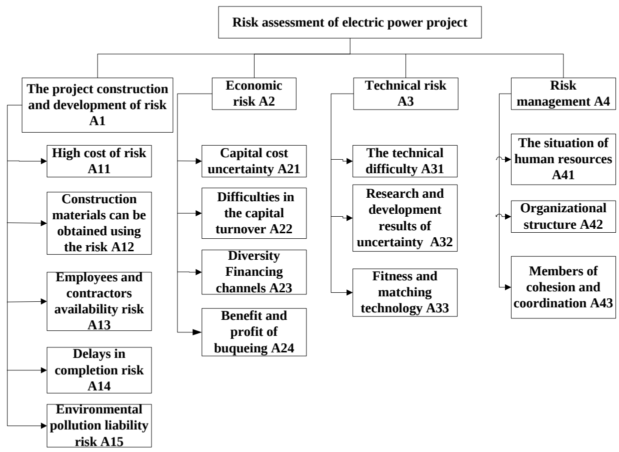

Figure 1. Electric project risk evaluation index system.

Compatibility Analysis of CIM Model and AHP The core of CIM model is “control interval and memory”. The so-called “control interval”refers to dealing with histogram of overlapped risk variables and reduce their possibility intervals in the process of calculation in order to reduce overlapped errors. In the specific calculation process, the smaller the decomposition of the corresponding possibility interval of the original overlapped variable X is, the more precise obtained results will be. CIM model can be divided into “series response model”and“parallel response model” and the appearance of each level of risk factors is random, which therefore can be applied into the parallel response method of CIM model [6].

$$p(D_i = d_i) = \sum_{i=1}^{n} p(D_1 = d_i, D_2 \le d_i) + \sum_{i=1}^{n} p(D_1 \le d_i, D_2 = d_i) \qquad (1)$$

In it, D_1, D_2 are 2 risk factors, d_i is the mid-value of class for the classification of risk index varying level, n is the varying interval grouping value of risk factors.

Layer analysis method decomposes complex problems into each component elements and group and form these component factors to the layer structure in accordance with the dominant relationship. It confirms the relative importance of each factor by paired comparison (comparison matrix), synthesizes the grading of experts and judgments of decision makers and confirms the total order of the relative importance of decision solutions. In hierarchical layer structure, setting the last layer element C as the standard, then its dominating next layer elements are u_1, u_2, …, u_n,the relative importance of standard C can be said as weight. For standard C,he comparison of the relative importance of n factors can obtain a paired comparison judgment matrix $A = (a_{ij})_{n*n}$, in it, a_{ij} is the proportional scale of element u_i and u_j compared to the importance of C. Judgment matrix A has the following properties: $a_{ij} > 0, a_{ij} = 1/a_{ij}, a_{ii} = 1$。If all factors of judgment matrix A satisfy $a_{ij} * a_{jk} = a_{ik}$, matrix A will be the consistent matrix.

CIM model is mainly applied into the calculation of the possibility of incident occurrence, and AHP method lies in the calculation of the weight relationship of risk factors, and their weight relations can be implemented with the means of experts'grading and etc. But the possibilities of each layer risk will be used in calculating the final total risk. Thus, CIM model can be introduced in this process. By applying CIM model, starting with the most bottom risk factor of risk incidents, the possibility of the last layer of risk incidents can be obtained and the risk value of the total risk project can be obtained by the comprehension of them both and the mission can be completed satisfactorily, which is more concise than simply applying one method only.

III. THE CONSTRUCTION OF ELECTRIC PROJECT RISK GREY VAGUE CIM MODEL

For researches on electric power project financing risk evaluation, the paper uses AHP method to confirm index weight and adopts grey vague evaluation to determine the possibility distribution of the most terminal layer of risk factors [5], and calculate the possibility distribution with the use of CIM parallel model, specific calculation flow is shown in Figure2:

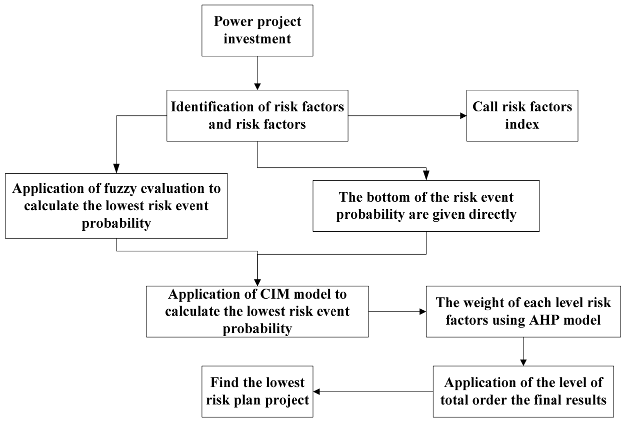

Figure 2. CIM -AHP model flow

Build Electric Power Project Risk Index Set: The evaluation index set of electric power financing risk can be expressed by A=(A1，A2，A3，A4), each risk index subset also includes t risk indexes in it, or $A_{ki} = (A_{k1}, A_{k2},,, A_{k4})$, (k=1，2，3，4)

Risk Weight Analysis: In accordance with expert opinions and layer analysis method, with the combination of project risk index system, the judgment matrix $A = (a_{ij})_{n*n}$ of the main risk layer of this project is built, among which a_{ij} is the proportional standard of element $A_i and A_j$ compared to the importance of C. Make normalization for each row of judgment matrix as equation(2)-(4). Vector w=(w1，w2，……w_n)t，or the approximate solution of the desired characteristic vector. Therefore, the maximum characteristic root of judgment matrix is calculated and shown as equation (5)

$$a_{ij} = \frac{a_{ij}}{\sum_1^n a_{ij}} \quad (i，j=1，2，…，n) \qquad (2)$$

$$w_i = \sum_{i=1}^{n} a_{ij} \quad (j，i=1，2，…，n) \qquad (3)$$

$$w_i = \frac{w_i}{\sum_1^n w_i} \quad (i=1，2，…，n) \qquad (4)$$

$$\lambda_{max} = \sum_i^n \frac{(Aw)_i}{Nw_i} \quad (i=1，2，…，n) \qquad (5)$$

Judgment matrix consistent index:

$$C.I. = \frac{\lambda_{max} - n}{n-1} \qquad (6)$$

Confirm the Membership of Second-Level Risk Index with Grey Vague Method:Set risk comment set as

V={v1,v2,v3,v4,v5}, v1,v2,v3,v4,v5express index comments as excellence, good, medium, worse, bad, corresponding project financing risk levels are low risk, lower risk, medium risk, higher risk and high risk, gift values of 1, 2, 3, 4, 5 points for 5 risk levels l, index grade is between two neighboring grade, corresponding grades are 1.5, 2.5, 3.5, 4.5.

Organize m experts to mark second-level index Qk,(k=1， 2， ， m) in accordance with the established risk level marking standard and obtain project financing risk judgment matrix Q= $(q_{ij})_{m*m}$. For the differences of limitations and recognition of expert levels, whitening values of grey number can only be given and whitening weight function needs to be confirmed in order to truly reflect the level of some kind expert marking belongs.

The 1st kind low risk (l=1),grey number belongs to the interval [0，1，2]，whitening weight function is expressed as the equation(7):

$$f_1(q_k)=\begin{cases}1 & q_k\in[0,1]\\ (2-q_k)/1 & q_k\in[1,2]\\ 0 & q_k\in[0,2]\end{cases}\qquad(7)$$

The 2nd kind lower risk (l=2), grey number belongs to the interval [0，2，4],whitening weight function is expressed as the equation(8):

$$f_2(q_k)=\begin{cases}2/q_k & q_k\in[0,2]\\ (4-q_k)/2 & q_k\in[2,4]\\ 0 & q_k\in[0,4]\end{cases}\qquad(8)$$

The 3rd kind medium risk (l=3),grey number belongs to the interval [0，3，6]，whitening weight function is expressed as the equation(9)：

$$f_3(q_k)=\begin{cases}q_k/3 & q_k\in[0,3]\\ (6-q_k)/3 & q_k\in[3,6]\\ 0 & q_k\in[0,6]\end{cases}\qquad(9)$$

The 4th kind higher risk (l=4)，grey number belongs to the interval [0，4，8]，whitening weight function is expressed as the equation(10)：

$$f_4(q_k)=\begin{cases}q_k/4 & q_k\in[0,4]\\ (8-q_k)/4 & q_k\in[4,8]\\ 0 & q_k\in[0,8]\end{cases}\qquad(10)$$

The 5th kind high risk (l=5)，grey number belongs to the interval [0，5，10]，whitening weight function is expressed as the equation(11)：

$$f_5(q_k)=\begin{cases}q_k/5 & q_k\in[0,5]\\ (10-q_k)/5 & q_k\in[5,10]\\ 0 & q_k\in[0,10]\end{cases}\qquad(11)$$

Calculate grey statistics of q_k belonged to 5 kind whitening function and normalize to obtain vector (k1，k2，k3，k4，k5). This vector expresses the vague membership of second-level risk index Akto to V to construct vague membership matrix $T=(t_{ij})_{5\times5}$) of second-level risk index. With the use of the parallel response model of CIM, as shown in equation (1), the possibility distribution of each level of electric power project financing risk index will be desired by each layer; last, in accordance with the weight of financing risk index, the possibility distribution of power project total risk will be obtained and the project financing risk will be evaluated with this result.

IV. EXAMPLE VERIFICATION

Some power generation plant project constructs 600MW homemade supercritical coal burning power generation units and this paper adopts the above described grey vague CIM evaluation model to evaluate the electric power project financing risk in order to measure the financing risk of this project.

In accordance with expert opinions and layer analysis method, with the combination of project risk index system, the judgment matrix of the main risk layer of this project is built and w=(0.082， 0.202， 0.170， 0.374， 0.172)t,it can be obtained with the use of equation（2）-（4）.

λmax= 5.26， judgment matrix consistent index C.I.= 0.065， random consistent ratio C.R.= 0.013<0.1， we can therefore know that this judgment matrix is acceptable, which can truly reflect the relations of each risk factor.

Select 15 experts in this field, in accordance with the established grading marking standard, mark second-level indexes and form the evaluation matrix, make grey vague treatment and construct the vague membership matrix T of second-level evaluation index.

$$T=\begin{bmatrix}0.018 & 0.352 & 0.374 & 0.219 & 0.037\\ 0.182 & 0.197 & 0.106 & 0.113 & 0.402\\ 0.135 & 0.131 & 0.469 & 0.143 & 0.122\\ 0.402 & 0.176 & 0.204 & 0.128 & 0.090\\ 0.309 & 0.243 & 0.251 & 0.181 & 0.016\\ 0.103 & 0.312 & 0.206 & 0.351 & 0.028\\ 0.209 & 0.326 & 0.248 & 0.185 & 0.032\\ 0.243 & 0.381 & 0.317 & 0.056 & 0.003\\ 0.284 & 0.253 & 0.157 & 0.134 & 0.172\\ 0.163 & 0.214 & 0.102 & 0.108 & 0.413\\ 0.147 & 0.231 & 0.269 & 0.239 & 0.114\\ 0.298 & 0.271 & 0.336 & 0.032 & 0.063\\ 0.103 & 0.376 & 0.213 & 0.143 & 0.165\\ 0.152 & 0.134 & 0.428 & 0.164 & 0.122\\ 0.142 & 0.296 & 0.324 & 0.185 & 0.053\end{bmatrix}$$

Apply CIM parallel response model, and calculate the possibility distribution of first-level risk index, which are shown in Table 1:

Table 1. Possibility distribution of first-level risk index.

Index	Risk rank				
	High-risk	Higher risk	Medium risk	Lower risk	Low risk
A1	0.0001	0.0414	0.0232	0.3033	0.4223
A2	0.0006	0.0314	0.0242	0.3723	0.5715
A3	0.0009	0.0114	0.0442	0.2972	0.6463
A4	0.0011	0.0024	0.0342	0.3421	0.6202

Possibility distribution of this electric power project risk is in Table 2.

Table 2. Possibility distribution of some electric power project risk

Risk rank	High-risk	Higher risk	Medium risk	Lower risk	Low risk
Probability	0.0012	0.0123	0.0487	0.3542	0.5836

From table 2, we can see that the possibility that the electric power project risk is low is the highest, which is 58.36%, demonstrating that the risk level of this project is low and this project can be implemented in the condition of the start of each level of risk strategies.

V. CONCLUSION

Risk factors affecting engineering projects are numerous; we should prioritize in numerous risk factors and analyze main risk factors affecting engineering investment.

CIM model and AHP method can be applied into the engineering investment risk analysis, CIM model emphasizes in the quantitative analysis of project risk, and AHP method emphasizes in the qualitative analysis of project risk, the combination of both can implement the complementation of their advantages, which can guarantee the combination of quantitative and qualitative analysis in the risk analysis and make analysis results more reliable.

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