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Contractor Evaluation Model For Large Project Based On Grey Relevancy

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Abstract: Large projects often face risks from technology, economy, nature, social and other aspects during development and construction. This paper describes a reasonable decision-making method of the general contractor based on Grey Relevancy. The primary weights of factors and evaluation of alternatives are determined by applying AHP. An illustration is presented to demonstrate the application of the method in contractor evaluation. The results are consistent with the results calculated by conventional contractor evaluation method. The research demonstrates that the method is objective and accurate, and is of an application value in the contractor evaluation.

Introduction

With the increasing scale of construction work, construction process not only involves technical problems, but also faces the natural environment, social environment, and manages the internal organization and other aspects of uncertainty. On the engineering contracting market, the EPC mode has became increasing important and can't be replaced depending on its own advantages. As we know, the EPC mode has several forms, like design-purchase-build, EPC turnkey contracting and etching this paper, we emphasize on the EPC turnkey contracting. However, how to choose the best general contractor is the most important point.

Contractor evaluation is concerned with evaluating the probability and impact of individual risk; the contractor evaluation methods which are widely used include expert grade method, Monte Carlo method and analytic hierarchy process (AHP). Despite the successful application of above evaluation methods, many problems remain: expert grade method is mainly based on the subjective judgments by the experts and the conclusions are approximate; Monte Carlo method is difficult to identify the correlations among factors. The AHP has some issues in the application: the imposed inconsistency due to the restriction of pair wise comparisons to a 1-to-9 scale and to the problematic correspondence between the verbal and the numeric scales; the variation in the verbal expressions from one person to another, as well as their dependence on the type of elements involved in the comparison. The method based on grey relevancy to study contractor factors of engineering projects is provided the important reference value for risk control of larger projects.

Contractor Evaluation System

Evaluation system of project general contractor

A theoretical model for contractor evaluation is presented to evaluate the contractor of a project. The model consists of levels of goal, criterion level, index level and alternatives. The level of goal is to explain the goal of contractor evaluation, the contractor factors are divided into several groups according to their criterion level, and every criterion level contains some factors. Combined with the alternatives which will be evaluated, an evaluation model is established. In the model, there are n kinds of risk sources which can be represented as $U=\{u_1, u_2, \ldots, u_i, \ldots, u_n\}$,and there are m factors in the risk source U_i, which can be represented as $V_{ij}=\{v_{i1}, v_{i2}, \ldots, v_{ij}, \ldots, v_{im}\}$.

The experts of construction select some factors and divide them into five criterion which are technical capability, management capability, construction experience, financial capacity and reputation. Thus, a contractor evaluation system is established, as shown in table 1.

Tab.1 Evaluation System

<table>
<tr><th>criterion level U</th><th>index level V</th><th>option</th></tr>
<tr><td>management capacity u_1</td><td>feasibility of project progress, v_{11}
Procurement management capability, v_{12}
Construction management capability, v_{13}
Design management capability, v_{14}
Company internal organizational structure,v_{15}</td><td rowspan="5">project general contractor A

project general contractor B

project general contractor C

project general contractor D</td></tr>
<tr><td>technical capacity u_2</td><td>Technology application ability, v_{21}
Machinery & equipment level, v_{22}
Engineering technology application ability, v_{23}
Technical staff qualification,v_{24}
Subcontractor Qualification,v_{25}</td></tr>
<tr><td>financial capacity u_3</td><td>Bank support (loan amount + guarantee amount), v_{31}
Company bidding ability, v_{32}
Profit-making capability , v_{33}
Financial stability, v_{34}</td></tr>
<tr><td>construction experience u_4</td><td>Average complete amount of similar projects contract in the past threey ears ,v_{41}
Good quality rate of similar projects, v_{42}
Contract amount of similar projects in construction,v_{43}
Company's compliance situation in thepast five years, v_{44}</td></tr>
<tr><td>reputation u_5</td><td>Litigation History,v_{51}
Related qualifications, v_{52}
Evaluation of this company from relevant partners, v_{53}
Experience of past failures, v_{54}
Received awards,v_{55}</td></tr>
</table>

Determine the grading value of various targets in each plan

Quantitative Analysis Target

Because of the different dimension and standards, we should carry on different standard to appraise each target and nondimensionalize these targets. Situations are shown as follows:

1) Maximum Target

$$f'_{ij} = \frac{f_{ij}}{\max f_{kj}} \tag{1}$$

$\max f_{kj}$ in (1) is the maximum optimum of target b value in these options

2) Minimum Target

$$f'_{ij} = \frac{\min f_{kj}}{f_{ij}} \tag{2}$$

$\min f_{kj}$ in (2) is the minimum optimum of target b value in these options

3) Certain Target

$$f'_{ij} = \begin{cases} 1 & f_{ij} = f_{j^*} \\ 1 - \dfrac{f_{ij} - f_{j^*}}{\max(f_{ij} - f_{j^*})} & f_{ij} \neq f_{j^*} \end{cases} \tag{3}$$

Qualitative Analysis Target

Some targets have no corresponding historical data, so they are needed to transform the qualitative analysis into the quantitative analysis with the application of Expert Grading Method.

We should guarantee that the experts grade each plan independently and understand the relative weight of each target, this project background, qualifications of each bidder, score rules and so on. The grading principle of Delphi Method is showed in the table2.

Tab.2 Grading Principle of Quantitative Target

Appraisal description	Excellent	Good	Better	Ordinary	Bad	Worse	Can't reach the demand
score	1	0.8	0.6	0.5	0.4	0.3	0.1

Establish Gray Relevancy Model

Gray Relevancy researches the rational degree between alternative plans and the primitive plan through determining the similarity of these curves.

$$r_{ij} = \frac{\min_i \min_j (f'_{ij} - 1) + \varepsilon \max_i \max_j (f'_{ij} - 1)}{(f'_{ij} - 1) + \varepsilon \max_i \max_j (f'_{ij} - 1)}$$

$\varepsilon \in (0,1)$ is the resolution coefficient, its value is 0.5

With the utility of AHP Method, we maintain the relative weight of each factor to realize the general goal: $w=(w_1,w_2,\ldots,w_n)^T$. Therefore, the alternative contractor and the primitive contractor form a relevance vector. That is:

$$r' = rw = r\left(w_1, w_2, \ldots, w_n\right)^T = \left(r_{01}, r_{02}, \ldots, r_{0n}\right)^T$$

As the result of the above expression, the bigger the r_{0n} , this contractor is more similar to the relative optimal contractor and is the best choice.

Empirical Analyses

The experts evaluate the weights of factors with the linguistic variables. The relative weight and rank of all facotrs: W=(0.0312, 0.0156, 0.0469, 0.0625, 0.0313, 0.0518, 0.0430, 0.0518, 0.0345, 0.0685 ,0.04, 0.2767, 0.04, 0.2767, 0.0139, 0.0278, 0.042, 0.042, 0.0135, 0.0187, 0.0187, 0.0059, 0.0059)^T

We use the provided data to make quantitative analysis about financial capability, construction experience of each bidder, and make qualitative analysis about management and technical capability and reputation. Thus, we can get the Grey Relevancy Matrix F and it is displayed in the table 3.

Tab.3 Grey Relevancy Matrix F

index level V	A	B	C	D	Optimalvalue
v_{11}	1	0.8	0.5	0.6	1
v_{12}	0.5	0.6	0.4	0.5	1
v_{13}	0.5	0.6	0.8	0.6	1
v_{14}	0.8	0.6	0.5	0.5	1
v_{15}	0.8	0.8	0.5	0.8	1
v_{21}	0.6	0.6	1	0.8	1
v_{22}	0.5	0.8	0.5	0.5	1
v_{23}	1	0.8	0.5	0.6	1
v_{24}	0.5	0.5	0.6	0.6	1
v_{25}	0.8	0.5	0.8	0.8	1
v_{31}	28	40	32	36	40
v_{32}	24	24	27	30	30
v_{33}	90%	100%	60%	70%	100%
v_{34}	90%	90%	70%	100%	100%
v_{41}	20	22.5	15	25	25

v_{42}	25	50	40	45	50
v_{43}	200	140	160	160	200
v_{44}	72	63	90	45	90
v_{51}	0.8	0.6	0.5	0.6	1
v_{52}	0.8	0.6	0.5	0.5	1
v_{53}	0.8	0.8	0.5	0.8	1
v_{54}	0.6	0.5	1	0.8	1
v_{55}	0.5	0.8	0.5	0.5	1

Use dimensionless method in grey incidence matrix:

$$F=\begin{bmatrix} 1 & 0.5 & 0.5 & 0.8 & 0.8 & 0.6 & 0.5 & 1 & 0.5 & 0.8 & 28 & 24 & 90\% & 90\% & 20 & 25 & 200 & 72 & 0.8 & 0.8 & 0.8 & 0.6 & 0.5 \\ 0.8 & 0.6 & 0.6 & 0.6 & 0.8 & 0.6 & 0.8 & 0.8 & 0.5 & 0.5 & 40 & 24 & 100\% & 90\% & 22.5 & 50 & 140 & 63 & 0.6 & 0.6 & 0.8 & 0.5 & 0.8 \\ 0.5 & 0.4 & 0.8 & 0.5 & 0.5 & 1 & 0.5 & 0.5 & 0.6 & 0.8 & 32 & 27 & 70\% & 100\% & 15 & 40 & 160 & 90 & 0.5 & 0.5 & 0.5 & 1 & 0.5 \\ 0.6 & 0.5 & 0.6 & 0.5 & 0.8 & 0.8 & 0.5 & 0.6 & 0.6 & 0.8 & 36 & 30 & 70\% & 100\% & 25 & 45 & 160 & 45 & 0.6 & 0.5 & 0.8 & 0.8 & 0.5 \end{bmatrix}$$

The grey relevancy value between the alternative contractor and the relative optimal contractor:

$$r' = FW = (0.840,0.968,0.9347,0.980)^T$$

According to the above equation, general contractor D is the best choice.

Conclusion

Depending on the development in large project contracting market, it is difficult to judge the capability of general contractor, improve the project quality, control the project cost and arrange the project time efficiently, so the paper present a contractor evaluation model for large projects based on grey relevancy. The result shows that the model can be used in the contractor evaluation of large projects development. The research indicates that the method proposed in this paper has its objectivity and stability, and is of applicable value in the risk evaluation for large projects.

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