Application of Entropy Measurement in Risk Assessment of the Engineering Project of Construction-agent System

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Abstract

This paper analyzes risks of the engineering project construction-agent system from other risks of other engineering projects, applies entropy measurement method to assess risks of a project of construction-agent system and analyses the result. The result shows that entropy measurement provides a simple and more objective method of analysis for risk of the engineering project management mode of construction-agent system.

Keywords: The project of construction-agent system; Entropy; Entropy weight; Risk assessment

1. Introduction

With the development of the investment system and the deepening reform of engineering project, construction-agent system as a government investment in non-operating items of management has drawn increasing attention. At present it is in the stage of early development, and the mechanism and the related system is not perfect. So, in practice, there are also many risks in practice. Based on this, this paper tries to start from the system engineering project risk analysis, finds out the source of the risk, and then submits the risk management strategies to construction-agent system to provide a reference for risk management.

2. Risk Assessment of the Project of Construction-agent System

2.1. Risk of the project of construction-agent system

Construction-agent system is a mode that project sponsors commissions the construction agency with appropriate qualifications to construct project, which is similar to PM/PMC, so it is called application localization of PM/PMC. Its application could better solve the problems which are caused by regardless of investment, construction and use in...
the traditional model of non-operating government investment. So it solves the professional project management problems, while creating benefits for the owners. On macroscopic, it further improves the level of domestic project management and improves investment efficiency of the whole society.

The implementation of construction-agent system transfers the risks to the construction agent, the implementation that professional construction agencies carry out project management can largely reduce the risk of the project. However, an effective construction management system has not established and relevant laws, regulations, construction are lagging behind. So the projects of construction-agent system have risk too. However, due to the projects of construction-agent system is different from others, so its risks are different from the risk of other projects’ risks. At first, because of the project sponsor is lack of understanding of construction-agent, the construction agency may collude design institute, appraisal institution and relevant government functional departments to project budget, or add project cost with construction units. Therefore, the risk of project actors is increased. Secondly, as a new management system, construction-agent system requests project sponsors and construction agencies separation, for departmental benefit, some owners may interpose the construction management in implementation. To some extent, it affects management of construction agencies, which increases the risk of project management process. In addition, due to long production cycle of building products, and the environmental impact is large. The project environmental risk factors show for policy risk, economic risk and legal risk.

In summary, the risks of Project Management Mode of Construction-agent System have three categories: the risk of the project environment factors, the risk of project management process and the risk of project actors. The risk index system is shown in Figure 1.

![Risk Index System](image)

**Fig. 1. The risk index system**

### 2.2. Construction risk

Currently project risk assessment used methods are Analytic Hierarchy Process (AHP) and Monte Carlo Simulation (MCS).

AHP decomposes the target into multiple objectives or criteria, then break down into several levels of multiple indicators (or criteria, constraints) to make decision. As a multi-criteria decision making methods, due to its pragmatic, systematic and concision, it has been widely used in practice and have achieved some results. But it also has its own drawbacks: firstly, it does not eliminate individual deviations interference when resolving the evaluation of experts, so the results may be due to one or two views of divorce appears larger the weight of the final results of
distortion; secondly, it deals with all expert opinions just by calculating the arithmetic mean for comprehensive weight calculation, which does not meet the majority principle, resulting in greater dispersion; at last, the trade-off analysis expert system is often a subjective, vague handling process, AHP is lack of such treatment ability. Using AHP to determine the risk level of analysis may produce extreme values which has a negative impact to the final result.

Monte Carlo Simulation is a statistical method by stochastic simulation and approximate solutions for solving approximate solution. The principle is using a random number generator to simulate the actual events that may occur. Monte Carlo simulation can deal directly with each risk factor of uncertainty, and show the impact of this uncertainty with the probability distribution of the forms. But the Monte Carlo simulation has some shortcomings to evaluate project risk: On the one hand, it requires relatively harsh conditions and needs more data with high precision, the distribution of some parameters and the error rate would be obtained through a large number of repeated trials. It is hard to be operable when analyzing conducting risk, the other the distribution density function can not be established due to insufficient amount of the data, then the final results can not be obtained; On the other hand, in order to get the exact probability density distribution, it requires a large number of calculations, this stunning time-consuming computation, which to some extent limits its use.

In engineering practice, most of the risk assessment decision-making is with great risk and huge uncertainty. A lot of data analysis showed that risk analysis is intended to describe or grasp some of the state of a system for risk management, reduce or control risk. Because we often get the information is inaccurate or incomplete. Risk measure is to calculate a particular object or program evaluation of environmental objectives in a known state, the object of evaluation or the potential risk to achieve goals. Due to the limitations of traditional risk analysis methods, this paper defines the risk as uncertainty of assessment or research objects, and presents a different levels of risk events for evaluation, use the information provided by the weighted quantity-entropy weight to assess the risk.

2.3. Application of entropy measurement method

Entropy method Based on the following ideas: In the multi-indexes assessment, at first various risk index value should be determined by experts, and then find out the entropy H and entropy weight $\omega$ with the given evaluation matrix $R$. Based on this thought, we can establish the following risk analysis of entropy model as follows:

To an evaluation problem, let $m$ as the number of indicators for the assessment, $n$ as the number of objects for the evaluation, in accordance with the principles of qualitative and quantitative combined, evaluation matrix $R'$ of multi-index about multi-object can be obtained.

\[
R' = \begin{bmatrix}
  r'_{11} & r'_{12} & \cdots & r'_{1n} \\
  r'_{21} & r'_{22} & \cdots & r'_{2n} \\
  \vdots & \vdots & \ddots & \vdots \\
  r'_{m1} & r'_{m2} & \cdots & r'_{mn}
\end{bmatrix}
\]

(1)

$R'$ is standardized to $R = (r_{ij})_{m \times n}$, $r_{ij}$ is called the value of evaluation objects $j$ on index $i$, also $r_{ij} \in [0,1]$, and

\[
r_{ij} = \frac{r_{ij} - \min_j r_{ij}}{\max_j r_{ij} - \min_j r_{ij}}
\]

(2)

If there are $m$ indexes and $n$ evaluation objects, the entropy of index $i$ is as follow:

\[
H_i = -k \sum_{j=1}^{n} f_{ij} \ln f_{ij} \quad i = 1, 2, \cdots, m
\]

(3)

In the formula, $k = \frac{1}{\ln n}$, $f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}}$, if $f_{ij} = 0$, $f_{ij} \ln f_{ij} = 0$.

In the evaluation problem $(m, n)$, the entropy weight of index $i$ is as follow:
Entropy weight has the following properties:

1. If the value on the index \( j \) of evaluation objects is the same, the entropy reaches the maximum value of 1, and the entropy weight is zero. This also means that the index does not provide decision makers with any useful information, the indicator can be considered to be canceled.

2. If the value on the index \( j \) of different evaluation objects varies widely, entropy is lower, entropy weight is larger. It shows that the index provides decision makers with useful information. At the same time on this issue, each object in the indicator there are obvious differences, attention should be taken.

3. The greater entropy of index is, the smaller its entropy is, the more unimportant the index is.

4. As the weights of the entropy weight, it has a special meaning. It is not in a practical sense of the importance factor of the index in the decision-making or evaluation, but the index of relative competition intensity sense, in the case of a given set of evaluation objects and the value of various evaluation indexes.

5. From the perspective of information theory, entropy weight represents the extent of the amount of useful information of the index in the problem.

6. The size of entropy weight is directly related to the object being evaluated. When the evaluation of the object is determined, according to the entropy of the evaluation index to adjust, increase or decrease in order to make more accurate and reliable evaluation to facilitate decision-making. Entropy weight can also be used to adjust the precision of evaluation, if necessary, re-determine the appraisal value and precision.

Evaluation of the risk value of the project is calculated by:

\[
R = \sum_{i=1}^{m} \omega_i H_i
\]

Gradation of risk level

Internationally ALARP is accepted criteria for risk acceptance criteria, which means under the premise of reasonability and practicability, various types of risk in the project should drop down as low as possible. The risk level and risk decision-making criteria of Agent Construction Management Mode are showed as the table 1.

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Risk Size</th>
<th>Risk Value</th>
<th>Risk Decision-Making Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1~4</td>
<td>0~0.16</td>
<td>Acceptable and do not have to look at the management</td>
</tr>
<tr>
<td>2</td>
<td>5~8</td>
<td>0.16~0.32</td>
<td>Acceptable and management review</td>
</tr>
<tr>
<td>3</td>
<td>9~12</td>
<td>0.32~0.48</td>
<td>Accept or refuse to avoid the senior management decision</td>
</tr>
<tr>
<td>4</td>
<td>13~16</td>
<td>0.48~0.64</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>5</td>
<td>17~25</td>
<td>0.61~1.00</td>
<td>Denied</td>
</tr>
</tbody>
</table>

3. Application of Entropy Measurement in Risk Assessment of the Project of Construction-agent System

Project: A City Park is located in the southeast corner of New District. Park covers an area of 180 thousand square meters, the park is 135.5 million RMB of total investment, including construction investment of 108.5 million RMB.

3.1. Establishment of evaluation set

Suppose domain of evaluation set is: \( Vi= \{ \text{Minor risk, Less risk, Medium risk, Higher risk, Risky} \} \) were used to represent.
3.2. Setting up the index evaluation system

The risk evaluation index system is established based on the engineering characteristics, showed in Figure 1.

3.3. Establish an evaluation matrix to calculate the risk factor values

There are the corresponding matrix of indexes Existing established by five experts using the Delphi method.

- The risk value of the project environment factors

\[
R_1' = \begin{bmatrix}
1 & 2 & 1 & 1 & 1 \\
2 & 2 & 1 & 1 & 1 \\
1 & 2 & 1 & 2 & 1
\end{bmatrix}, \quad R_1 = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 \\
1 & 1 & 0 & 1 & 0
\end{bmatrix}, \quad H_1 = (0.4307, 0.4307), \quad w_1 = (0.4676, 0.2662, 0.2662). \quad R_e = 0.2293
\]

- The risk value of project actors

\[
R_2' = \begin{bmatrix}
2 & 3 & 3 & 2 & 2 \\
2 & 1 & 1 & 3 & 1 \\
3 & 3 & 2 & 2 & 4
\end{bmatrix}, \quad R_2 = \begin{bmatrix}
0 & 1 & 1 & 0 & 0 \\
0.5 & 0 & 0 & 1 & 0 \\
0.5 & 0.5 & 0 & 0 & 1
\end{bmatrix}, \quad H_2 = (0.4307, 0.3955, 0.6460), \quad w_2 = (0.3726, 0.3957, 0.2317). \quad R_a = 0.4667
\]

- The risk value of project management process

\[
R_3' = \begin{bmatrix}
1 & 2 & 4 & 2 & 1 \\
1 & 1 & 2 & 1 & 3 \\
3 & 2 & 3 & 2 & 3 \\
4 & 1 & 4 & 2 & 1 \\
1 & 2 & 2 & 3 & 1
\end{bmatrix}, \quad R_3 = \begin{bmatrix}
0.3333 & 1 & 0.3333 & 0 \\
0 & 0 & 0.5 & 0 & 1 \\
0 & 0 & 1 & 0 & 1 \\
1 & 0 & 0 & 0.3333 & 0 \\
0 & 0.5 & 0.5 & 1 & 0
\end{bmatrix}, \quad H_3 = (0.5904, 0.3955, 0.6826, 0.6240, 0.6460), \quad w_3 = (0.1987, 0.2932, 0.1540, 0.1824, 0.1717). \quad R_m = 0.5631
\]

3.4. The total risk value of the project of construction-agent system

From the above calculation we can know

\[
R = (0.2293, 0.4667, 0.5631), \quad w = (0.2910, 0.2013, 0.1649). \quad R_p = 0.2535
\]

3.5. Risk assessment of project of construction-agent system

According to Table 1, \(0.16 < R_p < 0.2535 < 0.32\), the risk level of the project is level 2, which means the risk of the project is little, acceptable and need it management review.

Through comparing entropy and entropy weights of three categories factors, we can see that the entropy of project management processes risk and the risk of project actors and are bigger, which means experts are not sure about these two indexes, entropy weight are smaller; as to the risk of the project environment factors, the entropy is smallest and the entropy weight is biggest, which means experts are sure about this index. That also confirms the previous analysis of risk of project of construction-agent system, so entropy measurement method can guide to evaluate the risk of project of construction-agent system.

4. Conclusion

This paper, binding characteristics of the engineering project of construction-agent system, uses entropy weight to measure engineering project risk, from which we can recognize, entropy weight method can effectively reflect the different risk factors to the combined effect of the engineering project. This method is a reliable method, which should be promoted. Examples showed that this method is easy, Agent Construction Management Mode related
departments can use the evaluation results, expand the risk management to smooth implementation of the engineering project, as well as the accumulation of experience in the implementation of engineering project of construction -agent system.

References

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