Study on Risk Assessment of Project Site Selection Decision

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Abstract. Engineering site selection is the starting point and basis point for construction engineering to play its function. The quality of site selection decision is of great significance to the construction of engineering projects and the operation of follow-up facilities. This paper after analysing the four kinds of commonly used evaluation method of the build location decision-making risk assessment model, from the Angle of risk, location index system for using the G1 method and entropy weight method from two aspects of subjective and objective index system for empowerment, using grey correlation analysis and TOPSIS method to comprehensive evaluation, the risk alternative location to determine minimum risk value optional location, This model can provide reference and basis for project location decision.

Keywords: Project location · Risk assessment · G1 method · Entropy value method · Grey correlation analysis · TOPSIS method · Multi-objective decision making

1 Introduction

Project site selection problem is rational allocation of resources, planning, space and avoid risk and effective learning, has the high risk, because of the unreasonable location decisions often would limit the efficiency of engineering, affect the layout of the space, and once the site location to determine, in a short period of time is difficult to change, a series of adverse effects will last for a long time or even cause safety accidents. Therefore, the risk management of project site selection decision is particularly important. In the case that there are few referable project cases and alternative locations, it is a relatively feasible decision method to unify all evaluation indicators from the perspective of risk and evaluate them with appropriate methods.

2 Review and Analysis of Common Evaluation Methods

2.1 Entropy Value Method

Entropy method is an objective weighting method, which determines the weight according to the information provided by the observation value of each index in the index system. It has the following advantages: first, it can deeply reflect the ability to distinguish

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indicators, and determine the weight by the variation degree of the sample observation value; second, compared with the subjective weighting method, it has higher accuracy and credibility, and is not affected by the deviation caused by the lack of human ability and quality. Third, the weight can be obtained only by mathematical formula, the algorithm is simple, can be used in any process of determining the weight, and can be used in combination with other methods.

The disadvantages of entropy method are as follows: first, the degree of intelligence is not enough, and the influence of hierarchical relationship and correlation between indicators is not taken into account. If there is no guidance from business experience, the weight obtained may be distorted, so evaluators need to judge by themselves. Secondly, they can't solve the problems with order and hidden information, and often ignore the subjective intention of the evaluator. Third, it is highly dependent on the sample observation value, and the weight will also change with the change of the sample.

Entropy method is suitable for weight distortion caused by lack of business experience. If the sample size is small, it needs to evaluate or score with the participation of experts to give full play to its advantages.

2.2 G1 Method

As a typical subjective weighting method, G1 method has the following advantages: First, because the weighting process is directly determined by the authoritative experts in the research field, if the experts are experienced enough, the evaluation results can obtain good stability and inheritance; Second, the evaluation results can be more acceptable to people, and not affected by some original data; Third, there is no need to establish the judgment matrix, which omits the process of consistency test. Fourthly, there is no limit on the number of indicators of the same level, and the calculation of the method is very simple.

The shortcomings of G1 method are as follows: first, the method completely relies on the subjective concept of experts to make judgment, without the corresponding mathematical theory as the supporting conditions; Secondly, the final evaluation results are too arbitrary due to the influence of some experts' experience or knowledge reserve. Third, it is necessary to ensure that the evaluation index sequence meets the strong consistency condition, which makes the result less transparent and poor reproducibility.

2.3 TOPSIS Method

TOPSIS has the following advantages: First, it can make full use of the information of original data, quantitatively evaluate the advantages and disadvantages of different alternative positions, and the evaluation results are accurate and objective; second, there are no strict restrictions on the distribution of data, the number of indicators and the content of samples. It can not only be applied to the big data system data of multiple evaluation units and indicators, but also to the data of small samples. It can not only be flexible in application, simple in calculation, but also ensure the quantification of results.

The shortcomings of TOPSIS method are as follows: first, it is impossible to determine the appropriate number of indicators; Second, the advantages and disadvantages of the solution can only rely on the distance between the advantages and disadvantages of the scheme, in many aspects of consideration is relatively lacking, such as weight; Third, if there are too many alternative schemes, it cannot be classified and classified, which has limitations to a certain extent.

It should be noted that both the ideal optimal solution and the ideal worst solution should be selected from the scheme data rather than other reference schemes, otherwise large errors will be caused.

2.4 Grey Correlation Analysis

The advantages of grey correlation analysis are as follows: With a sample size and sample request is not high, can make up for the mathematical statistical methods need a large amount of data to do the support that you can't accomplish, to eliminate the "grey" composition in data, and the optimal standard is not fixed, choose value index of each scheme can be used in the optimal value, also can use or industry regulations of the state parameter values or be able to predict the optimal value; Second, the method is a combination of qualitative and quantitative evaluation method, which can solve the problem that it is difficult to count and quantify indicators, eliminate the negative impact brought by human factors, and will not be inconsistent with the results of qualitative analysis after quantification; Third, the calculation is small and very convenient, only a few representative samples are needed.

The disadvantages of grey relational analysis are as follows: first, it can only reflect the relative level of the evaluation object, but not the absolute level of the evaluation object; Second, in the case of evaluation only based on grey correlation analysis, "relative evaluation" has almost all the shortcomings; Third, the correlation degree is always positive, which cannot reflect all the correlations, because there is a positive correlation between the evaluation indicators, but also a negative correlation.

The mathematical method of grey correlation analysis is not a statistical method, so it is very suitable for poor information system. It is more practical when only a small amount of observation data leads to difficult decision making.

3 Construct the Risk Assessment Model of Site Selection Decision

3.1 Establish a Risk Assessment Index System

All factors that can affect the construction period and operation period of the project are unified from a risk perspective to build a risk assessment index system. Determine each index belongs to the positive index (the larger the value is, the greater the risk is), the negative index (the larger the value is, the less the risk is), the intermediate index (the closer to a certain value, the less the risk is) and the interval index (the closer to a certain range, the less the risk is).

3.2 The Weight of Project Site Selection Risk Index is Determined Based on Combination Weighting

3.2.1 The Objective Weight of Project Site Selection Risk Index is Calculated Based on Entropy Method

(1) Data normalization

Using extremum processing method to normalize the data obtained from the reference project:

1. For positive indicators:

$$x_{ij}^{*} = \frac{x_{ij} - \min\{x_{1j}, \cdots, x_{nj}\}}{\max\{x_{1j}, \cdots, x_{nj}\} - \min\{x_{1j}, \cdots, x_{nj}\}}$$

2. For negative indices:

$$x_{ij}^{*} = \frac{\max\{x_{1j}, \cdots, x_{nj}\} - x_{ij}}{\max\{x_{1j}, \cdots, x_{nj}\} - \min\{x_{1j}, \cdots, x_{nj}\}}$$

3. For intermediate indicators:
   Suppose $\{X_{ij}\}$ is A group of intermediate index data, and the optimal value is x_{best}

$$M = \max\{|x_{ij} - x_{best}|\}, x_{ij}^{*} = 1 - \frac{|x_{ij} - x_{best}|}{M}$$

4. For the interval type index:
   Suppose A is $\{X_{ij}\}$ set of interval-type index data, and the optimal interval is [a, b]:

$$M = \max\{a - \min\{X_{ij}\}, \max\{X_{ij}\} - b\}, x_{ij}^{*} = \begin{cases} 1 - \frac{a - x_{ij}}{M}, x_{ij} < a \\ 1, a \le X \le b \\ 1 - \frac{x_{ij} - b}{M}, x_{ij} > b \end{cases}$$

There are n reference projects and M standardized risk assessment indicators. After data normalization processing, a matrix $\left(x_{ij}^{*}\right)_{m \times n}$ of M × N is obtained.

(2) Finding the variability of risk assessment indicators (proportion of risk assessment indicators in different reference projects)
   Calculate the proportion p_{ij} of the i^{th} reference project of the j^{th} risk evaluation index:

$$p_{ij} = \frac{x_{ij}^{*}}{\sum_{i=1}^{n} x_{ij}^{*}} (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)$$

(3) The entropy of each risk evaluation index is worth the information entropy:
   Calculate the information entropy value e_j of the j^{th} risk evaluation index:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln p_{ij}, i = 1, 2, \cdots, n; j = 1, 2, \cdots, m.$$

(4) The information entropy redundancy is calculated:

$$g_j = 1 - e_j, j = 1, 2, \cdots, m$$

(5) Calculate the weight of each risk evaluation index:

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j}, j = 1, 2, \cdots, m$$

3.2.2 The Subjective Weight of Project Site Selection Risk Index Was Calculated Based on G1 Method

1. Determine the sequence relationship:

   Experts are invited to rank risk assessment indicators according to their importance. If xi is more important than x_j, it is denoted as $x_i \succ x_j$, "$\succ$" means better than. The evaluation indexes at the same level in the risk evaluation index set $\{x_1, x_2, \cdots, x_m\}$ are determined in the form of sequential relationship, that is, $x_1^* \succ x_2^* \succ \cdots \succ x_m^*$.
2. Judge the relative importance ratio between adjacent risk assessment indicators:

   Set the importance degree of index X as W, and determine the ratio of the importance degree of x_k^* and x_{k-1}^* r_k through expert evaluation.

$$r_k = \frac{w_{k-1}}{w_k} (k = m, m-1, \cdots, 2)$$

3. Calculate the weight of risk assessment indicators at all levels:

   According to the assignment value of r_k, the weight of the N^{th} index is calculated, and the weight of other risk evaluation indexes can be calculated from the weight w_k:

$$w_n = \left[\sum_{k=2}^{n} \prod_{i=k}^{n} r_i + 1\right]^{-1}$$

$$w_{k-1} = r_k w_k$$

If m experts evaluate the relative importance of n risk evaluation indexes, suppose that the weight of each index obtained by the Kth expert is w_i^k, and the personal weight coefficient of the v^{th} expert is dv ($0 < dv < 1, \sum_{i=1}^{m} d_v = 1$), then the cumulative weight of each index is:

$$w_i = \sum_{k=1}^{m} d_v w_i^k$$

If the ability, quality and experience of each expert are assumed to be equally important, that is, $d_v = 1/m$, then the weight of each indicator is the average weight of each expert:

$$w_i = \frac{\sum_{i=1}^{m} w_i^k}{m}$$

4. Comprehensive weight calculation of risk assessment indicators of each layer:
   Set the weight of key risk factor layer as W_a, sub-risk factor layer as W_b, and the comprehensive weight W' as:

$$W\prime = W_a^T \times W_b$$

3.2.3 Determine the Combination Weight of Risk Index of Position Location

The combination weights were calculated by Lagrange multiplier method:

$$\omega_j = \frac{\sqrt{w_j w\prime}}{\sum_{i=1}^{m} \sqrt{w_j w\prime}}$$

3.3 Comprehensive Evaluation Model Based on TOPSIS - Grey Correlation

Step 1: Data normalization

Standardized processing was carried out for the risk assessment index data of alternative locations. The method referred to the data standardized processing of objective weight determined by entropy method above.

Step 2: Data standardization and weighting

The purpose of standardization is to eliminate the dimensional influence of different indicators. If n alternative positions and m normalized evaluation indicators are provided, an m × n matrix $\left(x_{ij}\right)_{m \times n}$ can be formed, and the matrix elements are normalized and weighted:

$$Z_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}}$$

$$R = \left(r_{ij}\right)_{m \times n} = \left(z_{ij}\omega_j\right)_{m \times n}$$

Step 3: Determine the reference data sequence

The optimal value and the worst value of each index in the alternative position are selected to form positive and negative ideal solution sets R + and R −.

$$R^+ = \left\{R_1^+, R_2^+, \cdots, R_n^+\right\}$$

$$R^- = \left\{R_1^-, R_2^-, \cdots, R_n^-\right\}$$

Step 4: Calculate the Euclidean distance between the alternative position and the positive and negative ideal solution

The Euclidean distance to the positive ideal solution is:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} \left(R_j^+ - R_{ij}\right)^2}$$

The Euclidean distance from the negative ideal solution is:

$$D_i^- = \sqrt{\sum_{j=1}^{m} \left(R_j^- - R_{ij}\right)^2}$$

Step 5: Calculate the grey correlation coefficient from the alternative position to the positive and negative ideal solution

$$\zeta_{ij}^+ = \frac{\min\limits_{i=1}^{n}\min\limits_{j=1}^{m}\left|r_{ij} - r_i^+\right| + \rho \cdot \max\limits_{i=1}^{n}\max\limits_{j=1}^{m}\left|r_{ij} - r_i^+\right|}{\left|r_{ij} - r_i^+\right| + \rho \cdot \max\limits_{i=1}^{n}\max\limits_{j=1}^{m}\left|r_{ij} - r_i^+\right|}$$

$$\zeta_{ij}^- = \frac{\min\limits_{i=1}^{n}\min\limits_{j=1}^{m}\left|r_{ij} - r_i^-\right| + \rho \cdot \max\limits_{i=1}^{n}\max\limits_{j=1}^{m}\left|r_{ij} - r_i^-\right|}{\left|r_{ij} - r_i^-\right| + \rho \cdot \max\limits_{i=1}^{n}\max\limits_{j=1}^{m}\left|r_{ij} - r_i^-\right|}$$

Among them ρ is the resolution coefficient, the value is between (0,1), if the smaller ρ, the greater the difference between the correlation coefficient, the stronger the ability to distinguish, usually the value of ρ is 0.5.

Positive grey correlation coefficient matrix:

$$\xi_{ij}^+ = \begin{pmatrix} \xi_{11}^+ & \cdots & \xi_{1n}^+ \\ \vdots & \ddots & \vdots \\ \xi_{m1}^+ & \cdots & \xi_{mn}^+ \end{pmatrix}$$

Negative grey correlation coefficient matrix:

$$\xi_{ij}^- = \begin{pmatrix} \xi_{11}^- & \cdots & \xi_{1n}^- \\ \vdots & \ddots & \vdots \\ \xi_{m1}^- & \cdots & \xi_{mn}^- \end{pmatrix}$$

Step 6: Calculate the grey correlation coefficient between each alternative position and positive and negative ideal solution

$$\tau_i^+ = \frac{1}{n}\sum_{j=1}^{n} \xi_{ij}^+$$

$$\tau_i^- = \frac{1}{n}\sum_{j=1}^{n} \xi_{ij}^-$$

Step 7: Do dimensionless processing for grey correlation coefficient and Euclidean distance

$$M^* = \frac{M_i}{\max\limits_{1 \le i \le n}(M_i)}$$

M_i stands for $D_i^+, D_i^-, \tau_i^+, \tau_i^-$.

Step 8: Combine the results of TOPSIS and grey correlation analysis

Since D_i^+, τ_i^- are negative indicators, and D_i^-, τ_i^+ are positive indicators, the combined formula is:

$$X_i^+ = \alpha D_i^- + \beta \tau_i^+$$

$$X_i^- = \alpha D_i^+ + \beta \tau_i^-$$

α and β represent a preference for Euclidean distance and shape correlation, $\alpha + \beta = 1$.

Step 9: Calculate the comprehensive closeness of each alternative position and sort the alternative position

$$C_i^* = \frac{X_i^+}{X_i^+ + X_i^-}$$

The larger C_i^* is, the greater the risk value of the alternative position is; the smaller C_i^* is, the smaller the risk value of the alternative position is.

4 Conclusion

Quantitative and reasonable risk assessment of alternative locations is the premise of scientific site selection decision-making. In this paper, the construction of project site selection evaluation model from the perspective of risk is aimed at improving the decision-making ability of project site selection, which has certain practical value. It should be noted that: first, in the process of index system construction, the hierarchy should be clear and reasonable, otherwise, the weight will not conform to the objective law; Second, in the process of expert scoring, attention should be paid to the processing of expert scoring data, so that the results fully reflect the rich experience and professional level of experts.

Author in Brief

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