Research on the application of TOPSIS method in EPC risk assessment

Abstract:EPC projects are characterized by large scale, wide involvement, large number of personnel, and miscellaneous technologies, and face many and complex risk factors in the construction process. In the field of risk assessment, the TOPSIS method is often used in combination with risk identification technology, in order to correctly identify and assess risks, scientifically control risks, reduce adverse effects and improve management level. This paper discusses the advantages and disadvantages of TOPSIS risk assessment technology and the research status ofTOPSIS method, and puts forward its own views on the improvement of TOPSIS method, which can provide reference for construction risk decision-making of EPC projects.
Key words: Risk assessment; EPC; Combinatorial empowerment; MCDM

1Introduction

Risk management is a management method used to study the risk problems in the operation and management of enterprises around the 20s of the 20th century, with the purpose of providing a systematic, standardized and scientific risk management process, so that enterprises or organizations can effectively identify risks, assess risks, formulate countermeasures, and continuously improve the level of risk management in continuous optimization and improvement. Later, with the development of project management technology, Risk Management of project was formed.[1]

Risk management is an indispensable part of project management, with the development of society, due to the saturation of infrastructure construction and maintenance market, industry competition is becoming more and more fierce, the demand for large-scale construction projects is increasing, the technical requirements are becoming more and more demanding, the owner of the contractor who can provide integrated services for project construction is also getting higher and higher, the technical level and project management ability of enterprises are facing new challenges, so the project construction model gradually changes from the traditional model to the EPC model integrating design, procurement and construction. The EPC project general contracting model is a model in which the general contractor and the owner sign a contract, complete the entire planning and design, material procurement, and construction management of the construction project in accordance with the contract, and finally deliver the complete product to the owner, and the model is fully responsible to the owner for a series of overall planning and coordinated management in the implementation process, which makes the risk factors faced by the EPC project contractor more complicated. Therefore, risks should not only be identified, but also evaluated and managed.[2]

It can be seen from the relevant literature that in order to evaluate risks more scientifically, many scholars have proposed a variety of risk assessment methods.Among them, the TOPSIS(Technique for Order Preference by Similarity to an Ideal Solution) method is a very popular technology in the field of risk assessment, and is often used in combination with risk identification technology. The rest of this

article will briefly summarize the advantages and disadvantages of TOPSIS method, its research progress, its application in the field of EPC projects, and put forward its own views on the improvement of TOPSIS method and conclusions.[3]

2Study of the TOPSIS method

The TOPSIS method is one of the MCDM (Multi-criteria decision-making) methods, which makes full use of the information from the raw data and accurately reflects the gaps between the evaluation options. The basic idea is to calculate the distance between the normalized and normalized sample data and the positive and negative ideal solutions by assuming the positive ideal solution (PIS) and negative ideal solution (NIS), and obtain its relative closeness to the ideal scheme, so as to rank the advantages and disadvantages of each evaluation object.[4][5]

2.1 Advantages of the TOPSIS method

First, both subjective and objective indicators can be applied, and the decision-making of subjective and objective indicators can be considered at the same time; Second, it is easy to understand and use, that is, the method does not require a complex grasp of multivariate statistics or mathematics, so it can be quickly mastered and applied by decision-makers without a professional mathematical background. Third, it is robust enough to deal with complex problems with multiple imperfect indicators, and can effectively deal with potential outliers and problems such as errors or even missing data. Finally, it is flexible in use, which can respond to various complex and multi-dimensional decision-making problems at any time, and provide accurate and reasonable decision-making support for decision-makers.

2.2 Disadvantages of the TOPSIS method

First, the determination of the index weight is highly sensitive, and the determination of the index weight may have an impact on the final result. Second, there must be more than two research subjects to be used and the data for each indicator is required; third, the Euclidean distance has a failure situation; Finally, due to the reduction or addition of new decision-making schemes, the positive and negative ideal solutions have changed, resulting in the change of the order of advantages and disadvantages of the schemes, resulting in the problem of reverse order.

2.3Research progress of TOPSIS method

The TOPSIS method was first proposed in 1981 by Professor Hwang of Southeastern University in the United States. Later, in the multi-objective decision-making of the continuous scheme, Jin Qiong and Wu Qiuming proposed specific ways and methods to promote the application, and gradually introduced the TOPSIS method into the industrial economic benefits and engineering risk assessment for comprehensive ranking, creating new possibilities for investors in the multi-criteria evaluation of investment options.[6]

2.3.1 Weighted distance formula

In 2009, Meng Pengcheng used the weighted distance formula, which increased the authenticity of the data while retaining the original data, so as to obtain more objective and accurate ranking results. For making decisions on m schemes with n

indicators, the weighted distance formula is shown in formula (1) and (2):

$$S_i^+ = \sqrt{\sum_{j=1}^{n} w_j (t_{ij} - t_j^+)^2} \quad (1)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} w_j (t_{ij} - t_j^-)^2} \quad (2)$$

In the formula,i=1,2,…,m; j=1,2,…,n; w_j - weight; t_{ij}—Ideal solution; S_i^+—the distance from the weighted distance formula to the positive ideal solution;S_i^-—the distance from the weighted distance formula to the negative ideal solution.

2.3.2Weight Improvement Study

Guixiang Shen andShuguang Sun used the approximate median order method to calculate the empirical cumulative distribution function, and obtained the optimal distribution of the data through the AHP-EWM-TOPSIS model, which proved the reliability and practicability of the model.[7]

Qiuqin Lu proposed an improved entropy weight-grey correlation-TOPSIS model, which used a combination of subjective and objective methods to obtain the index weights, calculated the distance between the positive and negative ideal solutions, obtained the gray correlation level of each index and the ideal solution, and selected the best scheme according to the relative proximity.[8]

Qingqi Zhao constructed a SIES technology-economic evaluation model based on G1-anti-entropy weight-TOPSIS method, analyzed the evaluation indicators qualitatively and quantitatively, and overcame the problems that the AHP method needs consistency testing and the high sensitivity of the entropy weight method can easily lead to index failure.[9]

3 Application of TOPSIS method in EPC projects

As a multi-attribute decision-making method, the TOPSIS method has a faster calculation speed and more intuitive results than other multi-attribute decision-making methods, making it an important part of various decision support systems. TOPSIS is not limited by the sample size and the number of indicators, and can consider the influence of multiple factors at the same time, which is suitable for risk assessment with multiple groups of evaluation objects. The results are accurate and simple, suitable for a variety of comprehensive evaluation scenarios, with high applicability and practicability, and can cope with risk assessment in a variety of fields and working conditions, which is obviously suitable for risk assessment of EPC projects. The application research in EPC risk assessment has broad prospects. Specifically, the prospect of its application research is reflected in the following aspects.

First of all, as the complexity and scale of EPC projects continue to increase, the need for risk assessment is becoming more and more urgent. In view of this situation, the TOPSIS method provides an efficient and intuitive risk assessment method, which can provide more scientific support for the risk management of EPC projects, and is expected to become a commonly used risk assessment tool. Secondly, with the

development of information technology, various data processing and decision support systems are emerging, and the TOPSIS method will also be widely used. Using technologies such as data mining and machine learning, the data of EPC projects can be obtained and processed more accurately, thus ensuring the accuracy of the TOPSIS method. Finally, the TOPSIS method can be combined with other methods in the risk assessment of EPC projects to form a more complete risk assessment system. For example, fuzzy mathematics, analytic hierarchy process and other methods can be combined to evaluate and rank various risk assessment indicators to achieve a more comprehensive evaluation effect. Although the application of TOPSIS comprehensive evaluation method in EPC risk assessment has broad prospects, there are few empirical studies in the past ten years:

In 2011, Zhang Kunsheng used the risk evaluation index system and the entropy weight method and TOPSIS method to evaluate and analyze the risks of the general contractor of the EPC model joint venture on the basis of the case of the EPC model joint venture project, and obtained the risk ranking.

Taking an EPC project with a complex structure of energy performance contract investment with many stakeholders as an example, Jingmin Wang used the FAHP method to evaluate the risk of the EPC project risk system, and verified the evaluation results through TOPSIS. The evaluation results show that the evaluation indicators and methods are feasible and can better solve the risk assessment problem of EPC projects.[10]

Kabirifar analyzes and prioritizes EPC key activities in large-scale residential construction projects in Iran by using the TOPSIS method as a multi-attribute group decision-making technique. The results show that engineering design, project planning and control are important factors affecting project performance and play a pivotal role in project performance, which proves that the construction stage is more important than procurement, and emphasizes the risk control in the construction process.[11]

In order to mitigate financial risks such as inflation, liquidity, and credit, financial risks are assessed and prioritized based on the well-known fuzzy TOPSIS model. Jahantigh took an EPC project for the procurement and construction of an oil refinery as an example, and interviewed EPC project experts at all levels to classify and extract risks, and then prioritized risks according to the fuzzy TOPSIS model. Finally, the proposed model is compared with other models and expertise methods to determine its progress.[12]

4 Own ideas for improvement of TOPSIS

The G1 method is a subjective weighting method obtained through the optimization of the AHP method, which has the characteristics of flexible and scalable calculation, and does not need to construct the consistency of the judgment matrix test. The index weights were calculated according to the relative importance assignment between adjacent evaluation indicators.

The EWM method is an objective weighting method, which determines the objective weight according to the size of the index variation, and is less affected by

human interference. The calculation principle is to calculate the information entropy and entropy weight of the evaluation index by subjecting the original data to the dimensionless processing of the same trend and normalization

The CV method is an objective weighting method, and its weight is measured according to the volatility of the data, that is, the greater the numerical difference of the evaluated object on a certain index, the greater the information it carries, and the greater the weight.

The existing research shows that the index weights of the traditional entropy weight method have the shortcomings of distribution equilibrium, and the coefficient of variation is a parameter that characterizes the change between the eigenvalues of the evaluation index, which can overcome the shortcomings of the traditional entropy weight method, combined with the G1 method of subjective weighting, and assumes that there are l kinds of weighting methods through the linear weighted combination weighting method, then the calculation expression is shown in formula (3):

$$w_{\beta} = \sum_{s=1}^{l} \theta_s w_s \ (s=1,2,\ldots,l) \quad (3)$$

In the formula:w_s－Represents the weight of the s-th empowerment method; θ_S －Preference coefficient.

The mathematical evaluation model established on this basis can give full play to the advantages of both subjective and objective methods, and can make the evaluation results more objective and reasonable.

5 Concluding Remarks

At present, with the proposal of a large number of improved TOPSIS methods, this research idea combined with other methods provides new ideas and methods for the development of TOPSIS method, and also provides more scientific support for the risk management of EPC projects, provides useful solutions for contractors' decision-making problems, and makes the application scope and prospects of TOPSIS method more broad. According to the advantages and disadvantages of the traditional TOPSIS method in the application of risk assessment, the improvement of the TOPSIS comprehensive evaluation method is studied. In future research, the application of TOPSIS method in EPC project risk assessment and analysis in different engineering fields and scenarios should be further explored, and the theoretical framework and technical details of TOPSIS method should be improved, so as to better adapt to the actual situation and data to improve and optimize the mathematical model and calculation algorithm.

For example, with the development and application of artificial intelligence technology, it has high efficiency and accuracy in data processing, data analysis and automatic decision-making.

In short, with the development of EPC projects and the continuous strengthening of risk management, the application of TOPSIS method in EPC risk assessment has broad prospects, which can provide more scientific and effective risk management support for project managers, and is worthy of further research.

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