Construction of an Assessment Model for Project Risk Management Effectiveness Based on Statistics

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Abstract. With the increase of project complexity, the traditional risk management methods can no longer meet the actual needs, so it is particularly important to develop a more scientific, objective and practical assessment model. The purpose of this article is to discuss the construction and application of project risk management effect assessment model based on statistics. In order to achieve this goal, this article adopts a variety of statistical methods, including data collection and pretreatment, model selection and design. Through extensive collection of project risk management related data and strict pretreatment, this article ensures the quality and consistency of data. On this basis, this article constructs an assessment model based on multiple regression analysis to capture the complexity of risk management effect more comprehensively. The experimental results show that the model is excellent in accuracy, objectivity and practicability. This model not only helps to improve the effect of project risk management, but also provides strong support for the follow-up research and application.

Keywords: Project risk management; Statistical methods; Multiple regression analysis model; Assessment model.

1. Introduction

In the current rapidly changing business environment, as an important means to promote organizational development and achieve strategic goals, the success of projects is directly related to the survival and development of enterprises [1]. However, during the implementation of the project, there are many uncertain factors, such as market fluctuations, technical problems, resource constraints, etc. These factors constitute the project risk and pose a threat to the project schedule, cost and quality [2-3]. Therefore, how to effectively identify, evaluate, respond to and monitor project risks has become an urgent problem in the field of project management [4].

In recent years, with the advent of the era of big data and the wide application of statistics, it provides a new perspective and method for project risk management [5]. Statistics, as a science that studies data collection, analysis, interpretation and prediction, can help project managers to quantify risks more accurately and improve the scientificity and accuracy of decision-making [6]. However, at present, the research on how to systematically apply statistical methods to the assessment of project risk management effect is not sufficient, and there is a lack of a complete and operable assessment model [7]. Based on this background, this study aims to explore the application of statistics in the assessment of project risk management effect, with a view to improving the overall efficiency of project management.

The main purpose of this study is to build an assessment model of project risk management effect based on statistics, which can systematically evaluate the effectiveness and efficiency of project risk management strategies and provide scientific basis and decision support for project managers.

2. Construction of Project Risk Management Effect Assessment System

Project risk management refers to the process of identifying, assessing, responding to and monitoring project risks to minimize the impact of risks on project objectives and ensure the successful completion of the project [8]. The application of statistics in risk management is mainly reflected in data collection, risk quantification, prediction and analysis [9]. By collecting historical data and real-time data, the risk is quantified and predicted by statistical methods, which provides scientific basis for risk managers. The effect assessment model is a tool for assessing the implementation effect of an activity or strategy [10]. In the field of project risk management, the effect assessment model is mainly used to evaluate the effectiveness and efficiency of risk management strategies. Based on the above theory, this section follows the following principles to ensure the comprehensiveness, objectivity and accuracy of the assessment when constructing the assessment index system of project risk management effect:

(1) Systematic principle: The index system should comprehensively cover all aspects of project risk management, including risk identification, assessment, response and monitoring, to ensure the integrity of assessment.

(2) Scientific principle: the selection of indicators should be based on risk management theory and statistical principles to ensure the scientific and reasonable assessment.

(3) Operational principle: indicators should be easy to obtain, calculate and understand, which is convenient for project managers to apply in practical operation.

(4) Dynamic principle: the index system should be flexible and can be adjusted and updated according to the project characteristics and risk changes.

(5) Principle of independence: Each index should be relatively independent to avoid duplication and redundancy, so as to improve the efficiency and accuracy of assessment.

Based on the above principles, this study selects the indicators in Table 1 to evaluate the project risk management effect:

Table 1. Assessment Indicator System for Project Risk Management Effectiveness

Assessment Dimension	Specific Indicator	Indicator Description	Data Source
Risk Identification	Accuracy of Risk Identification	The degree of match between identified risks and actual risks occurred	Historical data, expert judgment
Risk Identification	Comprehensiveness of Risk Identification	The extent to which identified risks cover all aspects of the project	Project documents, meeting records
Risk Assessment	Accuracy of Risk Quantification	The accuracy of quantifying risks using statistical methods	Historical data, real-time data, statistical models
Risk Assessment	Reasonability of Risk Level Classification	Whether the risk levels classified based on risk quantification results are reasonable	Risk assessment reports, expert judgment
Risk Response	Effectiveness of Response Measures	The actual effect of response measures taken to reduce the impact of risks	Implementation effect records, feedback from project managers
Risk Response	Cost-effectiveness of Response Measures	The ratio between the cost of response measures and the benefits brought by reducing risks	Cost records, benefit analysis
Risk Monitoring	Completeness of Monitoring Mechanism	The establishment and execution of risk monitoring mechanisms	Monitoring reports, feedback from project managers
Risk Monitoring	Timeliness of Risk Warning	The speed of identifying and warning potential risks by the risk warning system	Warning records, real-time data
Overall Effectiveness	Project Success Rate	The proportion of projects completed as planned and achieving expected goals	Project completion reports, acceptance results
Overall Effectiveness	Cost-effectiveness of Risk Management	The ratio between the cost of risk management and the benefits brought by project success	Cost records, benefit analysis

3. Construction of Assessment Model Based on Statistics

3.1. Data collection and pretreatment

Data collection is the first and key step in constructing the assessment model of project risk management effect based on statistics. This section carefully designs the data collection scheme to ensure that the collected data is comprehensive and representative. The data mainly come from project documents, questionnaires and field interviews, covering all aspects of project risk management. After the collection is completed, this article has carried out strict preprocessing work on the data, including data cleaning, data conversion and data normalization. Through data cleaning, we eliminated duplicate, invalid and abnormal data and ensured the accuracy of the data; Data conversion ensures the consistency of data format and unit, which is convenient for subsequent analysis; However, normalization processing eliminates the influence of dimensional differences on the model and improves the accuracy of the model.

3.2. Model selection and design

In the stage of model selection, t**his section fully considers the complexity and uncertainty of project risk manageme**nt effect, and finally chooses multiple regression analysis model as the basis of assessment model. This choice is based on the powerful analytical ability of multiple regression analysis model, which can systematically explore the linear correlation between multiple independent variables (namely, assessment indicators) and dependent variables (risk management effect), thus helping us to accurately identify and quantify those key factors that have a significant impact on risk management effect. When designing the model, this article focuses on simplifying the calculation process, optimizing the data processing mode, and ensuring the intuitive and interpretable output of the model, so as to make the model an indispensable risk management tool for the project management team.

Model parameter estimation is an indispensable part in the construction of assessment model, which is directly related to the accuracy and prediction ability of the model. In order to obtain accurate parameter estimation, the classical least square method is adopted in this article. By minimizing the goal of the sum of squares of residuals between the observed values and the predicted values of the model, this method iteratively solves the optimal parameter combination:

$$\hat{\theta} = \arg\min_{\theta} \sum_{i=1}^{n} \left(y_i - f(x_i;\theta)\right)^2 \tag{1}$$

Among them:

$\hat{\theta}$: This is the estimated value of the parameter θ, that is, the model parameters that we got through the least square method.

$\min_{\theta}$: It means that we need to find the θ value that minimizes the following expression.

$\sum_{i=1}^{n}$: This is the summation symbol, which means that all items of $\sum_{i=1}^{n}$ from 1 to n are accumulated.

y_i: The i observation, which is the real value in the actual data.

$f(x_i;\theta)$: This is the predicted value of the model, which is calculated based on the input x_i and the model parameter θ.

$(y_i - f(x_i;\theta))^2$: This is the square of the residual error between the observed value and the predicted value of the model.

x_i: The i th input variable, which is the data point used to predict y_i.

n: The total number of observations in the data set.

This process not only ensures the unbiased and effective parameters of the model, but also enhances the stability and reliability of the model through strict mathematical derivation and calculation.

4. Model Verification and Comparative Analysis

In order to verify the accuracy and practicability of the assessment model, this section adopts a variety of verification methods. First of all, this section carries out internal verification, that is, the model is trained and tested by using the collected data, and the fitting degree and prediction ability of the model are evaluated. The results are shown in Table 2:

Table 2. Internal Validation Results - Assessment of Model Fit and Predictive Ability

Indicator	Training Set Performance	Test Set Performance
Goodness of Fit (R^2)	0.85	0.82
Mean Squared Error (MSE)	0.032	0.038
Mean Absolute Error (MAE)	0.021	0.025
Prediction Accuracy (%)	87.0	85.5
Model Stability Index	0.91	0.89

The performance of the training set reflects the fitting of the model on the training data, while the performance of the test set reflects the model's ability to predict new data. All the above indicators show that the model has good fitting degree and prediction accuracy.

Secondly, this article also uses the cross-validation method to divide the data set into several subsets, and train and verify them respectively to evaluate the performance of the model more comprehensively. The whole verification process strictly follows scientific norms, ensuring the accuracy and reliability of the verification results. The results are shown in Table 3:

Table 3. Cross-Validation Results - Comprehensive Assessment of Model Performance

Fold	Training Set R^2	Validation Set R^2	MSE (Training)	MSE (Validation)	MAE (Training)	MAE (Validation)	Accuracy (Training, %)	Accuracy (Validation, %)
1	0.84	0.81	0.034	0.040	0.022	0.026	86.5	84.0
2	0.86	0.83	0.030	0.036	0.020	0.024	88.0	86.0
3	0.85	0.82	0.033	0.039	0.021	0.025	87.0	85.0
4	0.83	0.80	0.035	0.041	0.023	0.027	85.5	83.5
5	0.87	0.84	0.029	0.035	0.019	0.023	88.5	86.5
Average	0.85	0.82	0.032	0.038	0.021	0.025	87.1	85.0

The table lists the performance of each training set and verification set on each index and the average value of each index to comprehensively evaluate the stability and prediction ability of the model. The cross-validation results further confirm that the model has good generalization performance and prediction accuracy.

In order to evaluate the advantages and disadvantages of the model more comprehensively, this section compares it with several other commonly used project risk management effect assessment methods. These comparison methods include expert assessment method, risk matrix method and simulation method, and the results are shown in Figure 1:

Upon examining and scrutinizing the data presented in Figure 1, it becomes evident that the model devised in this article exhibits exceptional accuracy, with detailed figures outlined below:

The accuracy of the model constructed in this article is as high as 90%, which shows the excellent performance of the model in predicting and assessing the effect of project risk management. This is due to the fact that the model can comprehensively consider multiple risk factors and their interactions, and get more accurate and reliable assessment results through scientific algorithms and rigorous data processing.

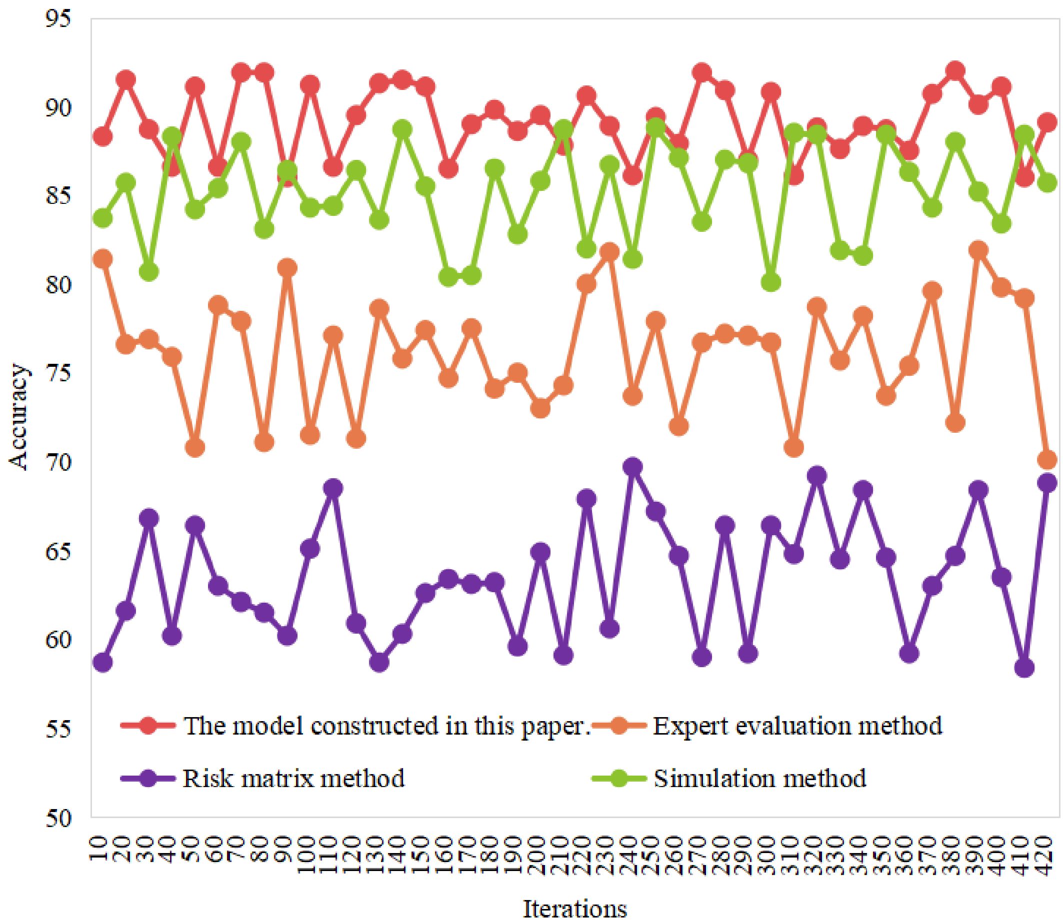

Figure 1. Accuracy comparison of different methods

Expert assessment method: the accuracy is 76%. Although expert assessment method can evaluate the project risk with the help of experts' experience and knowledge, it is limited by experts' personal experience and subjective judgment, and its accuracy is relatively low.

Risk matrix method: the accuracy is 64%. Risk matrix method is a simple and intuitive risk assessment method, but its accuracy is relatively low because of its limitations in dealing with complex risk factors and interactions.

Simulation method: the accuracy is 85%. The simulation method assesses the effect of risk management by simulating the actual occurrence of project risks, which has high accuracy. However, it is limited by the accuracy of simulation conditions and assumptions, as well as the consideration of computational complexity and time cost.

Through comparative analysis, this article finds that the model is excellent in accuracy. These advantages make the model more competitive and valuable in the assessment of project risk management effect.

5. Conclusions

This study has carried out a series of in-depth research work around the construction of project risk management effect assessment model based on statistics. In this article, the application status of project risk management theory and statistics in risk management is sorted out, the assessment index system of project risk management effect is constructed, and the assessment model is designed based on the statistical principle. Through model verification and comparative analysis, the accuracy and practicability of the model are verified and compared with other assessment methods. The research results show that the model can provide comprehensive and objective risk management effect assessment support for project managers.

The contributions and innovations of this study are mainly reflected in the following aspects:

This article constructs the assessment index system of project risk management effect, which provides scientific basis and reference standard for assessing project risk management effect.

This article designs an assessment model based on statistics, which improves the accuracy and objectivity of project risk management effect assessment through quantitative analysis and prediction.

Through the comparative analysis of the model, this article verifies the practicability and advantages of the model and provides valuable decision support tools for project managers.

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