Research on Risk Assessment of Life Cycle of Power Transmission and Distribution Engineering

Jing Nie\textsuperscript{1*}, Hongwei Yang\textsuperscript{1}, Xudong Zhang\textsuperscript{2}, Nan Xu\textsuperscript{1}, Yan Song\textsuperscript{1} and Dongchao Wang\textsuperscript{1}

\textsuperscript{1}Economic Technology Research Institute, State Grid Hebei Electric Power Supply Co. LTD, Shijiazhuang, 050021, China

\textsuperscript{2}State Grid Cangzhou Electric Power Supply Company, Cangzhou, 061000, China

\textsuperscript{1*}Corresponding author’s e-mail: 270477254@qq.com

Abstract. In recent years, the reform of the power industry system has entered a new stage. This puts higher requirements and challenges for the development of the power industry. Coupled with the high cost of the power transmission and transformation project and the complicated construction process, the risk factors in the power transmission and transformation projects have increased significantly. Therefore, strengthening risk management in power transmission and transformation projects can greatly reduce the cost of enterprises, and can greatly improve the economic benefits of enterprises. We analyze the possible risk factors in power transmission and transformation engineering and puts forward reasonable countermeasures, which has positive significance for the risk management of power transmission and transformation projects.

1. Introduction

At present, China's macroeconomic situation\cite{1} is still grim. In some industries, overcapacity and sales growth slowed down. Competition in the electricity sales market\cite{2} has intensified, and the revenue, profit, and investment capacity of power grid enterprises\cite{3} have been affected, and business management is facing a severe situation. In the face of severe conditions, grid companies need to change the way the company develops in a timely manner. As an effective means to improve the efficiency of power transmission and transformation projects\cite{4}, technical and economic management\cite{5}, its systematic and comprehensive risk assessment\cite{6} and prevention and control system\cite{7} needs to be established. Accurately identifying the risk factors in infrastructure projects\cite{8} is conducive to improving the awareness of project cost management risk prevention and control of all parties involved in power transmission and transformation projects, and is conducive to all parties to more effectively deal with complex and variable power transmission and transformation projects. From the perspective of technology, this paper divides the construction stage of power transmission and transformation projects in detail, combs and identifies the risks\cite{9} of power transmission and transformation engineering from the whole process, and evaluates the risk level of specific cases based on advanced index weighting and comprehensive evaluation methods. A risk prevention and control strategy is proposed for the key factors of power transmission and transformation engineering technology risks, and provides a theoretical reference for the development of specific work.
2. Risk Assessment Model of Power Transmission and Transformation Engineering Based on RS-SVM

2.1 Rough set index optimization and weighting method

Rough Sets theory is another new mathematical tool to deal with incompleteness and uncertainty after probability theory, fuzzy set theory and evidence theory. It can effectively analyze and deal with incomplete information such as inaccuracy, inconsistency and incompleteness, and discover hidden knowledge and reveal potential laws. Rough sets are not only suitable for analyzing quality attributes, but also for analyzing quantity attributes; reducing redundant attributes, and the reduction algorithm is relatively simple. The decision rule set derived from the rough set model gives the smallest knowledge representation. Rough set theory divides different evaluation factors into different levels by means of classification. The theoretical basis is set theory. Rough set theory is a collection of ways to describe concepts related to evaluation indicators.

Based on the identified technical and economic risk factors, in order to make it more scientific and reasonable to use the optimization method to evaluate the project risk level, the rough set method can be used to eliminate the indicators with repetition, crossover and redundancy. According to the screening mechanism of rough set import index, the collected data is first discretized and a rough set decision table is formed. Then the data is input into Rosetta software and the index is reduced by genetic algorithm to obtain the reduced index.

Specifically, the use of rough set theory for the reduction of evaluation indicators and the determination of their weights are divided into the following steps:

The first step is to construct a decision-making table for the risk assessment indicators of the whole process of power transmission and transformation engineering, \( S = (U, R, V, f) \), where \( U \) is the sample data collected through the questionnaire survey, which is the domain; \( R \) is the risk attribute factor involved in the optimization process of this indicator, namely the condition attribute.

Step 2: According to the rough set theory, calculate the set of equivalence class relations of the conditional attributes in the decision table, namely \( \text{IND}(P) \), and judge whether the conditional attribute is the relative reduction of the conditional attribute \( R \) according to the indistinguishable relationship of the rough set theory. If not, these condition attributes should not be streamlined. If the condition attribute is a relative reduction of the set \( R \), proceed to the next step to determine whether these can be reduced at the same time, or to reduce one of the condition attributes.

The third step: calculating the importance degree according to the set of equivalence class relationships obtained in the second step, the importance degree can reflect the classification change when the attribute is in the knowledge base. If the condition of the set \( R \) changes greatly after the condition attribute is removed, it indicates that the information attribute of the condition attribute is large and the degree of importance is large, and vice versa.

The fourth step is to calculate the weight of each evaluation index and the deviation degree of the index from the maximum weight index. The reduction of the redundant index is determined by the degree of deviation of the technical and economic risk assessment index of the whole process of power transmission and transformation engineering. In general, when the deviation of this indicator is greater than 90%, the indicator should be reduced, thereby streamlining the technical and economic risk assessment index system of the whole process of power transmission and transformation engineering.

2.2 Support vector machine comprehensive evaluation model

The basic principle of the whole process technical risk assessment of power transmission and transformation engineering based on support vector machine is:

Based on support vector machine, the basic principle of the whole process technical risk assessment of power transmission and transformation engineering is based on the established risk assessment index system of the whole process of power transmission and transformation engineering, and the characteristic value of each indicator in the indicator system is the score. The input vector of the vector
machine can be used to output the risk evaluation value of the whole process of the power transmission and transformation engineering using the trained model. When training the support vector machine model, first ask the experts to combine the evaluation model of the whole process technical risk assessment of the power transmission and transformation project with the evaluation index system, and score each evaluation index, and then use the SVM SteveGunn too box in MATLAB. The score value is normalized, and the processed sample data is combined with the insensitive band loss function $\varepsilon$ selected in this paper. The support vector machine model is used after continuous learning and training, and then the project sample is used as the test sample. The training accuracy of the zone detection model, when the training accuracy meets the established requirements, the model can be used as the model of the final risk assessment of the entire process of power transmission and transformation engineering.

The support vector machine classification theory is popularized and applied by introducing the $\varepsilon$ insensitive loss function. After introducing this function, the support vector machine classification theory can be used for function fitting. Based on this application, the support vector machine can also be applied to various estimation and prediction problems. Introducing the relaxation variables $\xi_i$ and $\xi_i^*$, the construction optimization problem is shown in equation (1).

$$\min_{w,b,\xi,\xi^*} \frac{1}{2}||w||^2 + C \sum_{i=1}^{n} (\xi_i + \xi_i^*)$$

$$s.t. \begin{cases} y_i - (w \cdot x_i) - b \leq \varepsilon + \xi_i \\ (w \cdot x_i) + b - y_i \leq \varepsilon + \xi_i^* \\ \xi_i, \xi_i^* \geq 0, \quad i = 1, \ldots, n \end{cases}$$

(1)

Among them, the constant $C$ is the penalty coefficient. The optimization problem of its dual space can be converted into formula (2).

$$\max_{\alpha, \alpha^*} Q(\alpha, \alpha^*) = -\frac{1}{2} \sum_{i=1}^{n} (\alpha_i - \alpha_i^*) (\alpha_j - \alpha_j^*) K(x_i, x_j) - \varepsilon \sum_{i=1}^{n} (\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} y_i (\alpha_i - \alpha_i^*)$$

$$s.t. \begin{cases} \sum_{i=1}^{n} (\alpha_i - \alpha_i^*) = 0 \\ \alpha_i \geq 0, \alpha_i^* \leq C \quad i = 1, \ldots, n \end{cases}$$

(2)

Where $a_i$ and $a_i^*$ are Lagrange multipliers. To solve this problem, get the best Lagrange multipliers $a_i$ and $a_i^*$, and get the fitting function, such as formula (3).

$$f(x) = \sum_{i=1}^{n} (a_i - a_i^*) K(x_i, x) + b$$

(3)

Among them

$$b = \frac{1}{N_{SV}} \left[ \sum_{0, \alpha_i^* < C} [y_j - \sum_{j, \alpha_j^* < C} (\alpha_j^* - \alpha_j) K(x_j, x_i) - \varepsilon - \frac{\alpha_i^*}{2C}] + \sum_{0, \alpha_i > C} [y_j - \sum_{j, \alpha_j > C} (\alpha_j - \alpha_j^*) K(x_j, x_i) + \varepsilon + \frac{\alpha_i^*}{2C}] \right]$$

Among them, the function $f(x)$ is the optimal regression function based on support vector machine in the whole process technical risk assessment of power transmission and transformation engineering. To obtain the sample-based nonlinear regression function in the original sample space, only the
calculation of the kernel function in the support vector machine is needed to obtain the corresponding coefficients, namely $\alpha$ and $b$.

3. Case analysis

Evaluation indicators screening and empowerment. Based on the technical and economic risk factors and the rough set index screening and simplification methods of the whole process of power transmission and transformation engineering, the technical and economic risk evaluation index system of the whole process of power transmission and transformation engineering is established, and the weight of the reserved indicators is assigned.

The SVM risk assessment results are based on the constructed support vector machine risk assessment model, and the five transmission and transformation engineering technical risk assessments are evaluated.

The first is the choice of kernel function. Combined with the data collected in this paper. If the collected data is not a priori, the selected kernel function should have smoothness when selecting the kernel function, and the four types provided in the LIBSVM toolbox. This paper will choose the radial function as the kernel function in this study. The radial function, the RBF kernel function, is shown in equation (4).

$$ K(x, y) = \exp\left(-\frac{\|x - y\|}{2\sigma^2}\right) $$

Where $\sigma$ is the parameter of the RBF kernel function, which represents the mean square error of the kernel function.

The second is the calculation of related parameters. After selecting the kernel function RBF, the function is used to determine the learning parameters c and g. The specific operation steps of the LIBSVM toolbox are as follows: prepare the training sample data according to the data format requirements of LIBSVM; perform the scaling operation of the data; use RBF The function determines the optimal learning parameters c and g. In this study, the K-fold Cross Validation method is used. Then the LIBSVM toolbox is used to determine the learning parameters.

It can be seen from the SVM evaluation value that project 1 has the lowest risk and project 4 has the highest risk. Key factors affecting the technical risks of each project include preliminary design depth and quality risk, preliminary design review quality risk, budget preparation quality risk, construction drawing design technical depth and quality risk, design change and on-site visa procedure normative risk, settlement normative Risks, settlement accuracy risks, etc. They need to be controlled and controlled in actual work.

4. Conclusion

Carrying out the risk assessment of power transmission and transformation engineering technology is conducive to the establishment of a scientific and rational technical risk prevention and control system and a sound risk prevention and control mechanism for the power grid companies, which will help to dig deeper the technical risks existing in power transmission and transformation projects. It is conducive to improving the risk management level of power transmission and transformation projects.

References

[1] Zhou H, Qian Y, Wang R. Research on cost risk assessment model of power transmission and transformation project based on bill-of-quantity valuation mode [J]. Modern Electronics Technique, 2017.

[2] Cai M, Sun Z, Li X L, et al. A Review on Ecological and Environment Impact Assessment of Municipal Power Transmission and Transformation System[M]// Advances in Computer Science, Intelligent System and Environment. Springer Berlin Heidelberg, 2011:593-598.
[3] Long H, Song S X, Zhou Y H, et al. Probabilistic safety assessment for power transmission and transformation maintenance project based on fault tree analysis and Bayesian network[C]// International Conference on Power System Technology. IEEE, 2014:1300-1305.

[4] Zhang Q H. Electromagnetic environmental management for high-voltage power transmission and transformation projects[J]. Electric Power Environmental Protection, 2008.

[5] Zhou M, Zhao S, Zhu J, et al. Cost Risk Evaluation of Power Transmission and Transformation Project Based on Support Vector Machine[J]. Journal of Wuhan University of Technology, 2016.

[6] Zhao Z Z, Bai L C, Hui-Fang S U, et al. Research on Construction Risk Assessment of EPC General Contract Transmission and Transformation Project with Design Institute as Leading[J]. Value Engineering, 2018.

[7] Peng Li, Su C. Study on the impact of power transmission and transformation projects on the vegetation and landscape pattern—A case study on 500kv transmission and transformation of Dagang-Chongzhou[C]// International Conference on Electric Technology and Civil Engineering. IEEE, 2011:4524-4528.

[8] Wei Q. Research on Grey Comprehensive Evaluation of Construction Risk of Power Transmission and Transformation Based on AHP and VPRS[J]. Journal of Wuhan University of Technology, 2018.

[9] Song R J, Wang X D. Research on assessment and analysis system of condition-based maintenance for power transmission and transformation equipment[J]. Relay, 2008.

[10] Yong-Ping D U, Jia-Cun L I, Wang Y L, et al. Revising and Application of Risk Assessment Model about Power Transmission and Transformation Equipments[J]. Journal of Anhui Electrical Engineering Professional Technique College, 2011, 17(1):82-104.

[11] He D, Zhang Y, Guo C, et al. Failure probability model of transmission and transformation equipment for risk assessment[C]// Power and Energy Society General Meeting. IEEE, 2016:1-5.

[12] Qi J X, Liu S L, Sun Z Y. Study on Post-Evaluation for the Power Transmission and Transformation Project Based on AHP-Fuzzy Comprehensive[J]. Advanced Materials Research, 2013, 756-759:2668-2672.