Research on Comprehensive Risk Assessment of Coal Enterprises

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ABSTRACT
The Coal industry is an important part of China's energy structure. It has created considerable economic benefits, provided huge employment space, and provided necessary fuel and raw material supply for other industries. This paper establishes a comprehensive risk evaluation index system for coal enterprises, establishes a fuzzy comprehensive evaluation model by using the method of fuzzy comprehensive hierarchy evaluation, and finally takes Heilongjiang Longmei Coal Company as an example. This method not only makes the evaluation result more scientific and objective, but also provides theoretical reference and practical significance for the safety production evaluation of coal enterprises.

Keywords-*Coal industry; Enterprise risk; Risk evaluation*

1. INTRODUCTION

Coal provides indispensable energy for China's industrial production. The coal industry has an important contribution to the national economy. China's economy has entered a new stage, which not only provides opportunities for the upgrading of the coal industry, but also brings unprecedented challenges to the coal industry. Because of the characteristics of the coal industry, there are a lot of uncertain risks in the production process of coal enterprises [1]. The key to prevent risks is to identify and evaluate the risk factors in the production process of coal enterprises [2]. Finally, the purpose of this study is to reduce or avoid the property losses caused by risks to coal enterprises, ensure safe production and realize long-term development.

The risk assessment of coal enterprises mainly evaluates the management and operation status of enterprises, as well as the production safety of enterprises. Mainly is whether the organizational structure of the enterprise is reasonable, whether the market operation is healthy, whether safety in production is implemented, and so on [3]. Through the analysis of the risks existing in coal enterprises, this paper establishes a complete risk assessment and control system for coal enterprises. It can help coal enterprises to better identify, evaluate and prevent risks, scientifically and effectively feedback the actual situation and existing problems of coal enterprises. The enterprise managers can intuitively understand the risks faced by enterprises, make correct decisions according to their risk tolerance, improve their internal safety management, avoid or reduce the losses caused by risks.

2. CONSTRUCTION OF COMPREHENSIVE RISK ASSESSMENT INDEX SYSTEM FOR COAL ENTERPRISES

The risk factors of coal enterprises are complex, diverse, interacting and transforming. Therefore, it is necessary to establish a complete and scientific risk assessment system for coal enterprises to fully and accurately reflect the actual risk situation of enterprises [4]-[5]. According to the principle of risk evaluation index system construction and the actual production and operation situation of coal industry, this paper selected five first-level evaluation indicators, including environmental factors, organizational factors, capability factors, market operation factors, safety production factors.

Environmental factors. Good business environment is conducive to the healthy and sustainable development of enterprises. The operating environment of coal enterprises mainly includes three factors: macro environment, industry environment and micro environment.

Organizational factors. The organizational structure is a form of interaction among the internal organizations of an enterprise. Reasonable organizational structure is the key to the sustainable development strategy of enterprises, and iIt also helps to optimize the functions of internal departments of enterprises. It includes the determination of the scope of management, the division of management functions, the establishment of institutions and other issues. Therefore, it can be divided into four factors: organizational adaptability, coordination and communication, organizational culture construction, and meticulous management.

Capability factor. Capability factor plays a very important role in the production and operation of enterprises, and it is an important factor for the sustainable development of enterprises. This paper mainly summarizes the capability factors of enterprises into four aspects: entrepreneurship capability, team learning capability, resource integration capability, innovation capability.

Market operation factors. Market operation refers to the market development behavior of enterprises through marketing, product development and brand management, in order to gain profits or increase market share. Enterprises focus on improving their market Competitiveness of products to maximize their interests. Market operation factors include product factors, price factors, channel factors and promotion factors.

Safety production factors. Safety guarantee in enterprises mainly refers to the safety of production work. Safety is the most important thing for employees. Safety production environment can stimulate the enthusiasm of employees and reduce the cost of production safety. This paper analyses the security factors from four aspects: the completeness of safety facilities, the exquisite degree of safety technology, the standardization of safety management and the perfection of safety system.

Tab.1 Comprehensive Risk Assessment Index System of Coal Enterprises

primary indexs	Secondary indexes
environmental factors (C_1)	macro environment (C_{11})
	industry environment (C_{12})
	micro environment (C_{13})
organizational factors (C_2)	organizational adaptability (C_{21})
	coordination and communication (C_{22})
	organizational culture construction (C_{23})
	meticulous management (C_{24})
capability factors (C_3)	entrepreneurship capability (C_{31})
	team learning capability (C_{32})
	resource integration capability (C_{33})
	innovation capability (C_{34})
	product factors (C_{41})
market operation factors (C_4)	price factors (C_{42})
	channel factors (C_{43})
	promotion factors (C_{44})
safety production factors (C_5)	safety facilities (C_{51})
	safety technology (C_{52})
	safety management (C_{53})
	safety system (C_{54})

3. STUDY ON COMPREHENSIVE RISK ASSESSMENT METHOD FOR COAL ENTERPRISES

3.1. Analytic Hierarchy Process to Calculate Weight of Index System

Analytic Hierarchy Process (AHP) decomposes the risks of coal enterprises and establishes a multi-level evaluation index system. Experts are invited to comment on the relevant elements at all levels and compare them in two or two ways [6]. According to the comparison results, the judgment matrix is constructed by using 1-9 level relative scales, and the eigenvalues and eigenvectors are obtained according to the matrix. Finally, the weights of each level factor to the superior factor are obtained. The specific steps are as follows:

3.1.1. Establish a comparison judgment matrix

The paper constructs the judgment matrix $A-B_i$. A is the superior target while B_i is the secondary target. It presents the importance degree of the secondary target to the superior target. Usually, it uses relative scales from Level 1 to Level 9 during the pairwise comparisons of elements. The judgment matrix is as follows:

$$A-B_i=\begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{pmatrix} \quad b_{ij}>0\ ,\quad b_{ij}=\frac{1}{b_{ji}}\ ,$$

$$b_{ii}=1$$

3.1.2. Calculate the weight of the index under a single criterion

The paper calculates the eigenvalue $\lambda_{\max}$ and eigenvectors W by using the power method or the inverse power method according to the judgment matrix $A-B_i$. The eigenvector W_j is the weight vector; w_{ij} indicates the importance degrees of the secondary index j to the higher level index i.

3.1.3. Carry out the consistency test to the matrix

As the construction of the matrix uses the expert subjective evaluation method, the judgment may be non-consistent, that is, A is more important than B, B is more important than C, and C is more important than A, which is contrary to the logical relationship. Therefore, it is needed to carry out the consistency test on the matrix.

The consistency test of the matrix is as follows: use the obtained eigenvector $\lambda_{\max}$ to calculate the consistency index $C_I = \frac{\lambda_{\max} - n}{n-1}$, then look up the table to obtain the random consistency index I_R. Substitute I_R into the matrix consistency formula $C_R = \frac{C_I}{I_R}$. If $C_R < 0.1$, it means that the matrix is consistent and there is no need to adjust the importance degree of the relevant elements; if $C_R \geq 0.1$, it means the matrix is not consistent. The importance degree of the relevant elements needs to be adjusted.

3.2. Calculating the final evaluation result by the method of fuzzy comprehensive judgement

Analytic Hierarchy Process (AHP) establishes the weights of each level of indicators relative to the upper level. In order to avoid the influence of subjective preferences in AHP on the results, we use the combination of AHP and fuzzy judgment to calculate the final evaluation results. Firstly, factor set and comment set are determined, and experts and relevant personnel of enterprises are used to evaluate the indicators. Subsequently, the final evaluation result can be obtained by establishing the decision matrix and multiplying it by the weight vector. The specific steps are as follows:

3.2.1. Setting up Factor Set and Comment Set

Determine the set of factors, which represents the collection of various factors affecting the evaluation object. In this paper, it represents the set of indicators at all levels of comprehensive risk of coal enterprises.

Determine the comment set, which represents the set of various evaluation results made by the evaluator to the evaluation object. In this paper, the evaluation results will be set as four levels: excellent, good, medium and bad, as the evaluation level of each evaluation index.

Tab.2 Risk Assessment Collection

Assessment Collection	excellent	good	medium	bad
Score interval	[8,10]	[6,8]	[4,6]	[0,4]

Assessment Collection	excellent	good	medium	bad
Midvalue of class	9	7	5	2

3.2.2. Computing the membership degree and judgment vector of the index

The questionnaire was designed by using the evaluation index system, and experts and managers were organized to score the questionnaire. The questionnaire was collected and the membership degree and judgment vector of each index were calculated. Assuming that the number of valid questionnaires received is 100, 30 questionnaires are excellent, 30 questionnaires are good, 20 questionnaires are medium, and 20 questionnaires are bad. Then the judgment vector of this index is $e = \{0.3, 0.3, 0.2, 0.2\}$.

3.2.3. Determining Decision Matrix

After calculating the membership degree and the decision vector of each index, the decision vector *e* of each index can be obtained, so the decision matrix *E* is:

$$E = \begin{pmatrix} e_{11} & e_{12} & e_{13} & e_{14} \\ e_{21} & e_{22} & e_{23} & e_{24} \\ \cdots & \cdots & \cdots & \cdots \\ e_{n1} & e_{n2} & e_{n3} & e_{n4} \end{pmatrix}$$

3.2.4. Fuzzy Judgment Method to Calculate Final Results

After the final decision matrix *E* is obtained, the corresponding index weight vector *W* is multiplied.The membership degree of each evaluation result *R* is obtained by using the fuzzy transformation.

$$R = W * E = (r_1, r_2, r_3, r_4)$$

It is normalized and multiplied by fuzzy discriminant vectors (Midvalue class of assessment) to get the final score of evaluation results.

4. EMPIRICAL ANALYSIS

4.1. Overview of Longmei Group

Heilongjiang Long Coal Mine Holding Group Co, Ltd. is a large coal-fired enterprise in China, among the top 100 coal enterprises in China. Longmei Group covers a wide range of business. Its coal products mainly include coking coal, lean coal, anthracite and coal washing. They are widely used in power generation, industrial boilers, coking and building materials. The other industries of Longmei Group mainly include electricity, logistics and

transportation, machinery manufacturing, real estate, construction and installation.

4.2. Risk Assessment Results of Longmei Group

According to the specific steps of the fuzzy comprehensive evaluation method, the relevant experts were invited to evaluate the risk situation of Longmei Group. In order to make risk assessment more scientific, experts from different fields are invited, including business leaders, risk assessment scholars and front-line staff. According to the above index system and evaluation method, the enterprise risk assessment is carried out. By summarizing and calculating the evaluation results of each index, we can get the specific scores of each level and index in the index system. As shown in Table 3.

Tab. 3 Risk Assessment Collection

Primary indexs	Score	Secondary indexes	Score
environmental factors (C_1)	7.162	macro environment (C_{11})	6.887
		industry environment (C_{12})	7.251
		micro environment (C_{13})	7.375
organizational factors (C_2)	7.556	organizational adaptability (C_{21})	7.675
		coordination and communication (C_{22})	8.100
		organizational culture construction (C_{23})	7.375
		meticulous management (C_{24})	7.450
capability factors (C_3)	7.570	entrepreneurship ability (C_{31})	7.750
		team learning ability (C_{32})	7.675
		resource integration ability (C_{33})	7.325
		innovation ability (C_{34})	7.400
market operation factors (C_4)	5.842	product factors (C_{41})	6.875
		price factors (C_{42})	5.921
		channel factors (C_{43})	5.364
		promotion factors (C_{44})	7.100
safety production factors (C_5)	7.127	safety facilities (C_{51})	7.150
		safety technology (C_{52})	7.350
		safety management (C_{53})	6.825
		safety system (C_{54})	7.235

By using the method of fuzzy judgment, the final risk evaluation results of coal enterprises can be obtained by multiplying the weights calculated, and the score is 7.048.

4.3. Analysis of evaluation results

The comprehensive risk evaluation score of Longmei Group is 7.048, and the final evaluation result is good. The safety condition of the enterprise is good, and it is in a stable state of operation.

Among the first-level indicators, the score of environmental factors was 7.126, which was mainly due to the improvement of coal industry environment in recent years. Coal price rose from 370 yuan/ton in 2016 to 660 yuan/ton in 2018. The scores of management

organizational factors and competence factors were 7.556 and 7.570 respectively. Enterprises have carried out market-oriented reforms, with 70,000 staff cut, and strengthened their internal management and organizational capabilities, making enterprises turn losses into profits. The score of safety management factors is 7.127. Since the fire accident in Shuangyashan No. 2 Coal Mine of Longmei Coal Mine in March 2017, the enterprise has obviously strengthened the management of coal safety production. But for the safety of miners'lives, although the evaluation is good, the work of safety production still needs to be improved. The lowest score of market operation factors was 5.842. This is because the market demand of Longmei Group is concentrated in Northeast China. With the decline of Northeast industry, the market demand is insufficient.

Among the secondary indicators, 16 are good, 2 are medium and 1 is excellent. The secondary indicators of management, organization and capability are generally good. These indicators belong to the internal safety indicators of enterprises and are the driving force of external safety indicators. They reflect the improvement of the production organization of enterprises, and also indicate that the risk situation of enterprises will gradually improve in the future. The second-level index score of safety production management factors is generally around 7, which indicates that safety production management of enterprises still needs investment, especially the standardization of safety management, which needs to be further strengthened. Among the secondary indicators of market operation factors, the scores of price factor and channel factor are 5.921 and 5.364 respectively, indicating that enterprises do not have advantages in market competition. Longmei Group is located in the northeast of China and is far away from the southern coal consumption market. The transportation cost problem restricts the Longmei market. It can make use of the advantages of maritime transportation to enter the market. One step to reduce costs, while expanding market channels.

5. CONCLUSION

This study is aimed at the comprehensive risk assessment of coal enterprises. The main contents include: the construction of risk evaluation index system of coal enterprises, the study of risk assessment methods of coal enterprises, the principle and basic steps of AHP-FCV risk assessment method, and the application of fuzzy analytic hierarchy process in risk assessment of coal enterprises. In the construction of the index system, according to the specific industrial characteristics and actual situation of the coal industry, 5 first-level indicators are constructed, and 19 second-level indicators are constructed under the guidance of the first-level indicators. Finally, Heilongjiang Longmei Group is selected as a case for empirical analysis. On the basis of fully understanding the situation of the enterprise, its risk situation is quantified. The current risk problems of the enterprise are analyzed, so as to provide an accurate target for the next management strategy of the enterprise.

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