Construction of Risk Indicator System for Overseas Expansion of Chinese Energy Mining Enterprises

Haiting Li
*Corresponding author e-mail: snowcherry619@sohu.com

China Academy of Natural Resources Economics, Beijing, China

Abstract: The article expounds the main risks faced by China's energy mining enterprises in overseas expansion, and constructs the index system of risk evaluation. On the basis of determining the index weight by using the analytic hierarchy process, the risk coefficient of China's energy mining overseas investment in Venezuela is calculated by using the fuzzy judgment method. This indicator system can objectively reflect the risk level of China's energy mining enterprises investing in typical countries, and help China's energy mining enterprises adjust their overseas expansion strategies and establish a risk prevention and control system for overseas expansion.

Keywords: risk indicator system; overseas expansion; construction

1 Introduction

At present, China's energy consumption demand is relatively strong, and its dependence on foreign energy is becoming increasingly severe [1]. The Chinese government and relevant enterprises have fully realized the importance of the safe supply of energy for the sustainable development of China's economy. Due to the limited reserves of energy resources in China, it is difficult to ensure energy security only by relying on its own resources. In order to seek a safe supply of energy, China's energy mining enterprises must expand abroad [2]. China's leading energy enterprises, such as Petro China, Sinopec and CNOOC, have had nearly 20 years of overseas expansion practice, including classic successful cases and typical lessons from failure. Therefore, it is of great practical significance to study the construction of the overseas expansion risk indicator system of energy mining enterprises on the basis of these practices.

2 Principles of index system construction

Firstly, we should follow the systematic principle. The risk assessment of overseas expansion of China's energy mining enterprises is a multiangle and multi-level systematic project, involving various political, economic, technical and management factors that affect the development of energy mining enterprises. Therefore, the setting of indicators should be able to systematically reflect the various risks faced by energy mining enterprises in their overseas expansion [3]. The established indicator system should have sufficient coverage, with clear hierarchy and strict logic between indicators.

Secondly, we should follow the principle of pertinence. The established indicator system must be consistent with the connotation and idea of risk assessment of overseas expansion of Chinese

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energy mining enterprises, and can reflect the main components of overseas expansion risk of Chinese energy mining enterprises, and can withstand the validity test of indicators. Therefore, the selection of evaluation indicators should be targeted, and the key condition indicators that affect the overseas expansion of China's energy mining enterprises should be selected, which is conducive to obtaining effective evaluation information and scientific evaluation.

Thirdly, we should follow the principle of feasibility. The selected evaluation indicators should be quantifiable and collectable. All indicators can be directly or indirectly obtained from existing statistical data and can be effectively measured, calculated and compared [4]. In addition, the connotation of evaluation indicators should be clear, the data should be standardized, and the statistical caliber should be consistent [5].

3 Index system

The overseas expansion of energy mining enterprises is to improve the competitive advantage of energy mining enterprises and find an effective way to ensure resource supply from the global resource allocation under the guidance of the concept of win-win cooperation. The overseas expansion of energy mining enterprises is a complex systematic project, facing a variety of potential risks such as politics and law, human resources, management, economy, culture and technology [6]. By analyzing the characteristics, motivations and reasons for success or failure of overseas mergers and acquisitions of energy mining enterprises in recent years, this paper constructs the green development indicators of mining provinces from four aspects [7]. It consists of four sub indicators of political risk, economic risk, engineering technology risk and management risk and 12 specific indicators. War and turmoil, nationalization and intervention of other countries constitute political risk sub indicators. Oil and gas resource price and development cost, fiscal and financial risks, and macroeconomic environment constitute economic risk sub indicators. Oil and gas resource potential assessment, oil and gas resource exploration technology, and oil and gas resource development technology constitute engineering technology risk sub indicators. Investment decision-making level, international talent acquisition and cultural conflict constitute sub indicators of management risk [8].

4 Determination of risk index weight based on AHP method

4.1 Introduction to AHP process

Analytic Hierarchy Process (AHP) is a decision analysis method that combines qualitative and quantitative methods to solve complex multi-objective problems [9]. This method combines quantitative analysis with qualitative analysis, judges the relative importance of the criteria for achieving each measurement goal with the experience of decision-makers, reasonably gives the weight of each criterion for each decision-making scheme, and uses the weight to find out the good and bad order of each scheme, which is more effectively applied to those problems that are difficult to be solved by quantitative methods [10].

The main steps to build the model by using the analytic hierarchy process are as follows:

(1) Build the target layer, criterion layer and indicator layer required by the analytic hierarchy

process, and determine the objectives and related factors to be analyzed.

(2) When constructing the judgment matrix, the reliability will be insufficient if only the qualitative values given by various understandings are integrated when the factors at all levels are assigned and scaled. Therefore, we cannot compare all factors together, but use the method of comparison in pairs to minimize the shortcomings of too strong subjectivity caused by the comparison of all factors together. The element aij in the judgment matrix is scaled by means of pairwise comparison, and the specific scaling meanings are shown in Table 1.

(3) The pairwise comparison matrix is calculated to calculate the maximum eigenvalue and eigenvector, and then its consistency is checked. The weight of each factor index can be calculated through the above method.

Table 1 The meaning of pairwise comparison matrix scale

Scale	Meaning
a_{ij}=1	i is as important as j
a_{ij}=3	i is slightly more important than j
a_{ij}=5	i is more important than j
a_{ij}=7	i is particularly more important than j
a_{ij}=9	i is extremely more important than j
a_{ij}=2n n=1,2,3,4	The median value of the above two adjacent judgments
a_{ij}=1/n n=1,2, ...,9	Judgment a_{ij} of comparison between factor i and j, then judgment a_{ji}=1/a_{ij} of comparison between factor i and j

4.2 Build risk assessment hierarchy and assign values

4.2.1 Establish risk assessment hierarchy

Specific risk assessment levels are shown in the following table (see Table 2):

Table 2 Risk levels of overseas expansion of energy and mineral enterprises

Target layer	Criterion layer	Indicator layer
Risk assessment on overseas expansion of China's energy mining enterprises	Political risks R_1	War and civil strife r_{11}
		Nationalization r_{12}
		Intervention by other countries r_{13}
	Economic risks R_2	Oil and gas resource price and development cost r_{21}
		Finance, taxation and finance r_{22}
		Macroeconomic environment r_{23}
	Engineering technology risk R_3	Oil and gas resource potential assessment r_{31}
		Oil and gas resource exploration r_{32}
		Oil and gas resources development r_{33}

	Managing risk R_4	Investment decision r_{41}
		International talent acquisition r_{42}
		Cultural conflict r_{43}

4.2.2 Construct the matrix and assign the value according to the method of pairwise comparison

(1) Criteria layer assignment

Risk assessment on overseas expansion of Chinese energy mining enterprises (A-B):

$$B = \begin{bmatrix} \frac{R_1}{R_1} & \frac{R_1}{R_2} & \frac{R_1}{R_3} & \frac{R_1}{R_4} \\ \frac{R_2}{R_1} & \frac{R_2}{R_2} & \frac{R_2}{R_3} & \frac{R_2}{R_4} \\ \frac{R_3}{R_1} & \frac{R_3}{R_2} & \frac{R_3}{R_3} & \frac{R_3}{R_4} \\ \frac{R_4}{R_1} & \frac{R_4}{R_2} & \frac{R_4}{R_3} & \frac{R_4}{R_4} \end{bmatrix} = \begin{bmatrix} 1 & 5 & 6 & 7 \\ 1/4 & 1 & 2 & 5 \\ 1/5 & 1/2 & 1 & 3 \\ 1/7 & 1/5 & 1/3 & 1 \end{bmatrix}$$

(2) Indicator layer assignment

Political risks (B-C1):

$$C_1 = \begin{bmatrix} \frac{r_{11}}{r_{11}} & \frac{r_{11}}{r_{12}} & \frac{r_{11}}{r_{13}} \\ \frac{r_{12}}{r_{11}} & \frac{r_{12}}{r_{12}} & \frac{r_{12}}{r_{13}} \\ \frac{r_{13}}{r_{11}} & \frac{r_{13}}{r_{12}} & \frac{r_{13}}{r_{13}} \end{bmatrix} = \begin{bmatrix} 1 & 3 & 7 \\ 1/3 & 1 & 4 \\ 1/7 & 1/4 & 1 \end{bmatrix}$$

Economic risks (B-C2):

$$C_2 = \begin{bmatrix} \frac{r_{21}}{r_{21}} & \frac{r_{21}}{r_{22}} & \frac{r_{21}}{r_{23}} \\ \frac{r_{22}}{r_{21}} & \frac{r_{22}}{r_{22}} & \frac{r_{22}}{r_{23}} \\ \frac{r_{23}}{r_{21}} & \frac{r_{23}}{r_{22}} & \frac{r_{23}}{r_{23}} \end{bmatrix} = \begin{bmatrix} 1 & 3 & 5 \\ 1/3 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{bmatrix}$$

Engineering technology risk (B-C3):

$$C_3 = \begin{bmatrix} \frac{r_{31}}{r_{31}} & \frac{r_{31}}{r_{32}} & \frac{r_{31}}{r_{33}} \\ \frac{r_{32}}{r_{31}} & \frac{r_{32}}{r_{32}} & \frac{r_{32}}{r_{33}} \\ \frac{r_{33}}{r_{31}} & \frac{r_{33}}{r_{32}} & \frac{r_{33}}{r_{33}} \end{bmatrix} = \begin{bmatrix} 1 & 1/2 & 5 \\ 2 & 1 & 7 \\ 1/5 & 1/7 & 1 \end{bmatrix}$$

Managing risk (B-C4):

$$C_4 = \begin{bmatrix} \frac{r_{41}}{r_{41}} & \frac{r_{41}}{r_{42}} & \frac{r_{41}}{r_{43}} \\ \frac{r_{42}}{r_{41}} & \frac{r_{42}}{r_{42}} & \frac{r_{42}}{r_{43}} \\ \frac{r_{43}}{r_{41}} & \frac{r_{43}}{r_{42}} & \frac{r_{43}}{r_{43}} \end{bmatrix} = \begin{bmatrix} 1 & 3 & 7 \\ 1/3 & 1 & 4 \\ 1/7 & 1/4 & 1 \end{bmatrix}$$

4.2.3 Index weight calculation

Firstly, calculate the eigenvector $W = (w_1, w_2, w_3, w_4)$ of the above matrix, normalize the eigenvector, calculate the maximum eigenvalue, and use the following formula (1) to calculate:

$$\lambda_{max} = \sum_{i=1}^{m} \frac{(BW)_j}{nw_i} \quad (1)$$

Secondly, perform consistency verification for the calculated λ_{max}:

$$C_I = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

Thirdly, compare the results obtained from formula (2) with the random consistency indexR_ITable (see table 3). The consistency judgment indicators are as follows: when the results meet formula (3), it means that the consistency verification is passed; If not, the judgment matrix needs to be adjusted until it passes the consistency check.

$$C_R = \frac{C_I}{R_I} < 0.1 \quad (3)$$

Table 3 Corresponding table of random consistency index R_I

n	1	2	3	4	5	6	7	8	9	10
R_I	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Finally, the weight of indicators calculated according to the above methods through consistency verification is shown in the following table (see table 4):

Table 4 Weighted values of overseas expansion indicators of energy mining enterprises

Level I indicatorsR_i	Weights of primary indicators	Secondary indicatorsr_{ij}	Secondary index weight
		r_{11}	0.5915
R_1	0.6136	r_{12}	0.3141
		r_{13}	0.0945
		r_{21}	0.5667
R_2	0.2082	r_{22}	0.3079
		r_{23}	0.1255
		r_{31}	0.3952
R_3	0.1237	r_{32}	0.5363
		r_{33}	0.0685
		r_{41}	0.5915
R_4	0.0544	r_{42}	0.3141
		r_{43}	0.0945

5 Risk coefficient analysis based on fuzzy comprehensive

Evaluation method

The evaluation of risk often involves many different factors, and everyone has a certain angle to analyze the risk, so there will be different understandings of the same risk factor. Under such circumstances, it is necessary to take certain methods to deal with these different factors, and different people's different understandings of the same factor. On this basis, the method to draw a fair conclusion is called the fuzzy comprehensive evaluation method.

The specific process of the fuzzy comprehensive evaluation method is as follows: step one is to build a fuzzy set of multiple factors of the evaluation target; Step 2: Determine the weight of each risk index through AHP method; The third step is to build a risk evaluation set and a single factor risk judgment matrix; Step 4 is to calculate the risk assessment vector, and calculate the risk assessment results by combining the risk assessment judgment conditions.

5.1 Define the risk assessment set for overseas investment of energy mining enterprises

Four levels are used to evaluate risks, including general risk, large risk, serious risk and catastrophic risk. It is recorded as P = $\{P_1, P_2, P_3, P_4\}$={general risk, large risk, serious risk, catastrophic risk}, and quantitatively described as P = {0.1,0.3,0.7,1}.

5.2 Build a single factor risk evaluation matrix and calculate the risk coefficient

In this paper, Venezuela is taken as an example for the process of relevant assignment and operation:

$$R_1 = \begin{bmatrix} 0.5915 \\ 0.3141 \\ 0.0945 \end{bmatrix} \times \begin{bmatrix} 0.6 & 0.4 & 0 & 0 \\ 0 & 0 & 0.8 & 0.2 \\ 0.7 & 0.3 & 0 & 0 \end{bmatrix}$$

$$= [0.4211 \quad 0.2650 \quad 0.2513 \quad 0.0628]$$

$$R_2 = \begin{bmatrix} 0.5667 \\ 0.3079 \\ 0.1255 \end{bmatrix} \times \begin{bmatrix} 0 & 0.3 & 0.7 & 0 \\ 0 & 0.8 & 0.2 & 0 \\ 0 & 0.9 & 0.1 & 0 \end{bmatrix}$$

$$= [0.0000 \quad 0.5293 \quad 0.4708 \quad 0.0000]$$

$$R_3 = \begin{bmatrix} 0.3952 \\ 0.5363 \\ 0.0685 \end{bmatrix} \times \begin{bmatrix} 0 & 0.4 & 0.6 & 0 \\ 0 & 0.2 & 0.8 & 0 \\ 0 & 0.4 & 0.6 & 0 \end{bmatrix}$$

$$= [0.0000 \quad 0.2927 \quad 0.7073 \quad 0.0000]$$

$$R_4 = \begin{bmatrix} 0.5915 \\ 0.3141 \\ 0.0945 \end{bmatrix} \times \begin{bmatrix} 0.5 & 0.5 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 \end{bmatrix}$$

$$= [0.5031 \quad 0.4970 \quad 0.0000 \quad 0.0000]$$

The results of fuzzy comprehensive evaluation are calculated on the basis of the above. After calculation, Venezuela's risk coefficient=0.2858 × 0.1+0.3360 × 0.3+0.3397 × 0.7+0.0385 × 1=0.4057.

$$R = \begin{bmatrix} 0.6136 \\ 0.2082 \\ 0.1237 \\ 0.0544 \end{bmatrix} \times \begin{bmatrix} 0.4211 & 0.2650 & 0.2513 & 0.0628 \\ 0.0000 & 0.5293 & 0.4708 & 0.0000 \\ 0.0000 & 0.2927 & 0.7073 & 0.0000 \\ 0.5031 & 0.4970 & 0.0000 & 0.0000 \end{bmatrix}$$

$$R = [0.2858 \quad 0.3360 \quad 0.3397 \quad 0.0385]$$

6 Conclusion

Based on the analysis of the main risks faced by China's energy mining enterprises in overseas expansion, this paper sorts out the primary and secondary weight indicators of the risk factors of China's energy mining enterprises in overseas investment. The weights of these indicators are calculated by AHP method based on the research conclusions of other studies on these factors and some data. Then, through the method of fuzzy judgment, these weight indicators are judged, and the current risks of China's energy mining enterprises investing in Venezuela are quantitatively analyzed to obtain the corresponding risk coefficients. The next step is to further improve the indicator system and calculation model by expanding the data sources of empirical analysis.

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