Analysis of Mineral Resources Security Factors Based on AHP Method

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Abstract. In the process of social and economic development, mineral resources, as one of the production factors, are indispensable. If we want to maintain economic growth, we must have a sustainable and stable input of mineral resources. As China's economy has entered the late stage of industrialization, the problem of scarcity of mineral resources has become more and more serious. On the basis of influencing factors of mineral resources security, this paper establishes the evaluation index system of mineral resources security in China, and then uses AHP method to determine the weight of each influencing factor, which reflects the actual situation of the sample.

Key words: Mineral resources security, Influential factors, evaluating index system AHP.

1. Main factors affecting mineral resources safety
Mineral resources security is a complex system which involves many factors, such as resources, economy and politics at home and abroad. There are 4 main factors that affect the safety of mineral resources.

1.1. Resource factors.
Resource factor is one of the most fundamental factors affecting mineral resources safety. The more abundant a country's own resources, the higher the degree of economic development security, the higher the security of resources supply.

1.2. Economic factors.
The impact of economic factors on the safety of mineral resources is not only reflected in whether there is sufficient foreign exchange to support imported resources and resist price increases, but also plays a decisive role in optimizing the allocation of domestic resources and imported resources to achieve overall optimum.

1.3. Technical factors.
For mineral resources, technological progress will reduce the cost of mining. For resources with constant marginal mining costs, the reduction of marginal mining costs caused by technological progress will slow down the conversion to alternative resources. For resources with increasing marginal exploitation costs, technological advances have led to the discovery of more resources now than in the future. Technological advances will reduce extraction costs over a period of time, which may be quite long,
even though resources are non-renewable and marginal costs will eventually rise. But at the same time, significant technological advances in the development and utilization of new energy sources will generally enhance the situation of resource security in all countries.

1.4. Institutional supply factors.
In fact, the system supply factor has a great impact on the safety of mineral resources, and its effect mainly depends on the relevant laws, regulations and policies formulated by the national government on the development, use and consumption of resources.

2. The relationship between factors affecting mineral resources safety

2.1. The importance of affecting the safety of mineral resources.
Generally speaking, economic factors and institutional supply factors have great influence on mineral resources safety. But it is not absolutely necessary to give timely importance ranking in combination with specific time and space.

2.2. Correlation between factors affecting mineral resources safety.
Factors affecting mineral resources safety often show correlation. For example, if a country's economic strength is strong, there is much room for choice in mineral resources security policy. They often make optimal decisions between imported resources and the development of their own resources; technology, especially new technologies for the development and utilization of resources. It will reduce the dependence on the original resources and enhance the safety of mineral resources. In addition, there is a strong correlation between economic factors and technological factors.

2.3. The dynamic nature of mineral resources safety.
Although the factors affecting the safety of mineral resources can ordinate the importance of mineral resources in general, the above-mentioned factors may change in ordination with the difference of space and time. That is, the above factors play a certain dynamic role in affecting the safety of mineral resources.

3. Establishment of safety evaluation index system for mineral resources

3.1. Establishment of index system for mineral resources safety assessment.
1) According to the factors affecting the safety of mineral resources, the characterization quantities of each influencing factor are listed in detail. In this process, we should take all the factors into consideration and list as many as possible, without considering the correlation between them.
   2) According to the availability of the data of the indicators, the indicators were further eliminated by correlation analysis, principal component analysis or expert investigation.
   3) Repeat the second step repeatedly, so that the evaluation of mineral resources security indicators in the premise of as little as possible, with greater characterization.

3.2. Establishment of safety evaluation index system for mineral resources.
According to the above ideas, the index of safety assessment for mineral resources is established.
Table 1. Indicators for safety assessment of mineral resources

| Target layer | Variable layer | Safety impact trend |
|--------------|----------------|---------------------|
| Domestic resource endowment factors (B1) | C1: Reserves account for the proportion of world reserves. + | |
| | C2: Reservoir ratio - | |
| | C3: Per capita resources + | |
| | C4: Proven reserves + | |
| | C5: Resource quality + | |
| Mineral resources safety (A) | C6: External dependence on mineral resources consumption - | |
| | C7: Comparison of production speed and consumption speed + | |
| | C8: Domestic mineral output accounts for the world's total share. + | |
| | C9: Concentration of import sources - | |
| | C10: Transportation distance and safety of transportation routes + | |
| | C11: Unit GDP consumption of mineral resources + | |
| National security guarantee (B3) | C12: Competitiveness of domestic mineral company + | |
| | C13: The proportion of reserves controlled by the state abroad + | |
| | C14: Strategic reserve + | |
| | C15: Rationality and completeness of policy + | |
| | C16: Economic strength + | |

4. AHP method for mineral resources safety assessment

The analytic hierarchy process referred to as AHP is a multi-criteria decision-making method combining qualitative and quantitative analysis. This method is to construct a hierarchical structure model after in-depth analysis of the nature of complex decision problems, influencing factors and internal relationships, and then use less quantitative information to mathematically process the thinking process of decision making to solve multiple goals and multiple A decision-making method for a complex problem of criteria or no structural characteristics. Due to its practicability and effectiveness in dealing with complex decision-making issues, it has been widely used in economic planning and management, energy policy and distribution.

The use of AHP is divided into the following five steps:

1) Identify the problem. Determine the overall goal of the system through a deep understanding of the system under study. Clarify the scope of the decision-making, the criteria for achieving the goals, and the constraints.

2) Establish a hierarchy. According to the difference of the target and the realization of the difference of functions, the system is divided into several hierarchical levels, such as the target layer, the criterion layer, the plan layer, etc., and the hierarchical relationship between the hierarchical structure and the factors is illustrated by a graph.
(3) Pairwise comparison, establish a judgment matrix, and solve the weight vector. The value of the judgment element reflects the decision maker's understanding of the relative importance of each factor, using the 1 to 9 scale and its reciprocal scale method. It is necessary to calculate the weight vector of each judgment matrix and the composite weight vector of the overall judgment matrix.

(4) Hierarchical single sorting and its consistency test. The single ordering is the solution \( W \) of the eigenvalue problem \( AW=\lambda_{max}W \) of the judgment matrix \( A \), which is normalized to become the ranking weight of the corresponding factor of the same level to the relative importance of a certain factor of the previous level. The consistency test of the judgment matrix is performed by calculating the consistency index \( CI=\frac{\lambda_{max}-n}{n-1} \). When the random consistency ratio \( CR=\frac{CI}{RI}<0.1 \), the hierarchical single-sequence structure is indicated. Satisfactory consistency. Here, the average random consistency index of the representative judgment matrix can be obtained by looking up the table according to the actual situation.

(5) The total order of the levels. Calculate the composite weights of each layer element on the system target, and perform total sorting to determine the importance of the lowest level elements in the hierarchy in the overall target. Finally, based on the analysis of the calculation results, consider the corresponding decision.

The weights of the safety evaluation indicators are determined according to AHP, and the weights of each indicator are determined by the Analytic Hierarchy Process (AHP). The weight results are shown in Table 2, Table 3, Table 4 and Table 5.

**Table 2. One of the results of the evaluation index weights1**

| Variable layer | C1 | C2 | C3 | C4 | C5 | C6 |
|----------------|----|----|----|----|----|----|
| C1             | 1  | 4  | 1/4| 3  | 5  | 0.2544 |
| C2             | 1/4| 1  | 1/3| 3  | 4  | 0.1567 |
| C3             | 4  | 3  | 1  | 5  | 7  | 0.4657 |
| C4             | 1/3| 1/3| 1/5| 1  | 2  | 0.0771 |
| C5             | 1/5| 1/4| 1/7| 1/2| 1  | 0.0461 |

From Table 2: \( \lambda_{max} =5.383 \), \( CI=0.0958 \), \( RI=1.12 \), \( CR=0.0855<0.1 \).

**Table 3. Evaluation Index Weights 2**

| Variable layer | C6 | C7 | C8 | C9 | C10 | C11 | weight |
|----------------|----|----|----|----|-----|-----|--------|
| C6             | 1  | 3  | 1/3| 4  | 5   | 1/2 | 0.2298 |
| C7             | 1/3| 1  | 1/3| 3  | 4   | 1/3 | 0.1375 |
| C8             | 1/2| 3  | 1  | 2  | 4   | 1/4 | 0.1550 |
| C9             | 1/3| 1/4| 1/2| 1  | 2   | 1/5 | 0.0659 |
| C10            | 1/5| 1/5| 1/4| 1/2| 1   | 1/6 | 0.0399 |
| C11            | 2  | 3  | 4  | 5  | 6   | 1   | 0.3719 |

From Table 3: \( \lambda_{max}=6.4498 \), \( CI=0.0900 \), \( RI=1.24 \), \( CR=0.0726<0.1 \).

**Table 4. Evaluation Index Weights 3**

| Variable layer | C12 | C13 | C14 | C15 | C16 | weight |
|----------------|-----|-----|-----|-----|-----|--------|
| C12            | 1   | 1/4 | 1/5 | 2   | 3   | 0.1158 |
| C13            | 4   | 1   | 1/3 | 4   | 5   | 0.2715 |
| C14            | 5   | 3   | 1   | 5   | 7   | 0.4843 |
| C15            | 1/2 | 1/4 | 1/5 | 1   | 2   | 0.0794 |
| C16            | 1/3 | 1/5 | 1/7 | 1/2 | 1   | 0.0490 |

From Table 4: \( \lambda_{max}=5.1995 \), \( CI=0.0499 \), \( RI=1.12 \), \( CR=0.0445<0.1 \).
Table 5. Evaluation Index Weights

| Index code | B1 | B2 | B3 | B4       |
|------------|----|----|----|----------|
| B1         | 1  | 3  | 6  | 0.6393   |
| B2         | 1/3| 1  | 4  | 0.2737   |
| B3         | 1/6| 1/4| 1  | 0.0869   |

From Table 5: $\lambda_{max}=3.0540$, CI=0.0270, RI=0.58, CR=0.0466<0.1. The overall consistency is:

CI = 0.0958 × 0.6393 + 0.0900 × 0.2737 + 0.0499 × 0.0869 = 0.0902
RI = 1.12 × 0.6393 + 1.24 × 0.2737 + 1.12 × 0.0869 = 1.1527
CR = CI/RI = 0.0902/1.1527 = 0.0783 < 0.1

5. Conclusion

From the above analysis, it can be seen that the structure of single ranking at all levels has a satisfactory consistency, and the overall ranking has a satisfactory consistency. According to the weights, of the 16 indicators affecting the safety of mineral resources, the per capita resources, the proportion of reserves controlled by the state in foreign countries and the weight of strategic reserves are the largest, indicating that these three factors play the strongest role in determining the safety of mineral resources in China. This system can be used to evaluate the safety of other mineral resources. The results can provide a method basis and reference for the government departments and management agencies to formulate mineral resources development policies and formulate resources reserve strategy.

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