Construction of green development index system of China inter provincial mining industry

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Abstract. The green development index of China inter provincial mining industry is put forward in this paper, and its background significance is analyzed. Based on the concept of combining green and development, the index system framework is constructed from four aspects of resource saving, environment-friendly, structure optimization and management strengthening. Delphi method and analytic hierarchy process are used to calculate the index weight, and the index standardization and index calculation method are proposed. The index system can evaluate the level of green development of China inter provincial mining industry, and objectively show the differences in time and space of green development of mining industry. It is of great significance to promote the green development of mining industry and accelerate the construction of green mine.

1. Background

Green development of mining industry has formed an international consensus. At the end of 2017, China officially released the green development index for the first time, indicating that green development will be the baton of China mining development in the future. It will realize the transformation and upgrading of mining industry, and it will also be the inevitable requirement for achieving high-quality development. Since 2007, the development of green mining industry in China has gone through a glorious course of 10 years. By January 2020, the Ministry of Natural Resources had published the National Directory of Green Mines, in which 953 mines had been included. The establishment of green mining development demonstration zone is also being actively carried out. The development of green mining industry and the construction of green mines have become the important direction and starting point of mineral resources management and mining industry development under the new situation. Through compiling the provincial mining green development index, a set of monitoring index system and index measuring system of mining green development were established. It can objectively show the green level of China regional mining industry, and make horizontal and vertical comparison and analysis, which is of great significance to promote the green development of mining industry.
2. Principles of index system construction
First, it is necessary to implement the concept of combining green and development, which not only reflects the current green level of mining in all provinces, but also reflects the development trend of green mining. We should pursue both green and development.

Secondly, it is necessary to highlight the characteristic indicators of green development of interprovincial mining industry. In the selection of indicators, we should highlight the characteristic indicators that need to be paid attention to in the process of green development of mining industry in each province, such as green mine completion rate, management system, social effect.

Thirdly, for those regions without regional indicators, its relevant indicators do not participate in the calculation of the total index, its weight apportionment to other indicators, so as to reflect the difference.

Finally, we should adhere to the principles of openness, fairness and justice, and take the open authoritative data as the basic data for calculation. The basic data used in the index system of interprovincial mining green development should all come from the published Yearbook or authoritative index data published by relevant departments.

3. Construction of index system

3.1. Index system
The green development of mining industry is to realize the optimal allocation of mineral resources and minimize the impact of ecological environment, which is guided by the concept of green development. Around the two dimensions of green and development, the interprovincial green development index of mining industry is constructed from four aspects, based on the perspective of system theory emphasizing the coordinated development of resources, environment and economy and society. It is composed of four sub-indexes, resource saving, environment-friendly, structure optimization, management strengthening and 16 specific indicators.

From the perspective of consumption of energy resources and green exploitation of resources, the sub index of resource saving is constructed by specific indicators such as energy consumption of 10000-yuan mining output value, land occupation of 10000-yuan mining output value, target rate of mine three-rate level, comprehensive utilization rate of mine gangue, waste rock and tailings.

From two aspects of environmental damage and environmental protection, the sub index of environmental friendliness is constructed by the specific indexes of waste gas, waste water, smoke (powder) dust, solid waste and the recovery and treatment rate of mine geological environment.

From the aspects of supply structure, mine structure and demonstration area construction, the sub index of structural optimization is constructed by specific indicators such as green mine completion rate, the number of demonstration areas, the proportion of large and medium-sized mines, and the proportion of clean energy production.

From the perspective of government, enterprise and society, the sub index of management strengthening is constructed by specific indicators such as system construction, number of abnormal list and serious illegal list, social effect, etc.

3.2. Weight determination
Since the mining green development index is a multi-objective decision-making problem, the weight of each index should reflect its importance to the green development of mining industry. In order to ensure the fairness and objectivity of index measurement, this study uses Delphi method and analytic hierarchy process (AHP) based on domestic and foreign related research. Firstly, the Delphi method is used to get the expert scoring results. Secondly, the analytic hierarchy process is used to establish the pairwise comparison judgment matrix. Finally, the weight of each sub index is calculated. Because the specific indicators can reflect the green development of mining industry from different aspects, it is of little significance to do too detailed weight treatment for specific indicators, and therefore, equal weight treatment is adopted.
Table 1. Interpretation, data source and calculation method of inter provincial mining industry green development index system

| Sub-index                                      | Indicator                                      | Connotation of indicators                                                                 | Data source                                           | Calculation method                                                                 |
|-----------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------|
| Resource saving (Weight 0.25)                 | Energy consumption of 10000-yuan mining output value (t standard coal / 10000-yuan) | The ratio of total energy consumption and output value of mining enterprises, reflecting the energy utilization efficiency in the mining production process. | China Energy Statistics Yearbook                      | Energy consumption of 10000-yuan mining output value = mining energy consumption / mining output value |
|                                               | Land occupation of 10000-yuan mining output value (km² / 10000 yuan) | The proportion of the cumulative land occupied by mining and the output value of mining, reflecting the utilization efficiency of land resources in the mining production process. | China Land and Resources Statistical Yearbook         | Land occupation of 10000-yuan mining output value = mine area / mining output value in the same period |
| Rate of mine three-rate level                 | Rate of mine three-rate level                 | It reflects the standards of mining and recovery rate, mineral processing recovery rate and comprehensive utilization of resources of mining enterprises. | Disclosure of exploration and mining information by mining owners | The standard rate of mining recovery rate = the number of Mines meeting the mining recovery rate standard / the number of mines whose mining recovery rate should be assessed × 100% The standard rate of ore dressing recovery rate = the number of Mines meeting the standard of mineral processing recovery rate / the number of mines whose mineral processing recovery rate should be assessed × 100%. The standard rate of comprehensive utilization of mineral resources = the number of Mines reaching the level of comprehensive utilization of mineral resources / the number of mines that should be comprehensively utilized × 100%. The average value is obtained by using the above three target rates. |
| Comprehensive utilization rate of gangue, waste rock and tailings (%) | Comprehensive utilization rate of gangue, waste rock and tailings (%) | It reflects the effective utilization of waste solids and associated resources in the mining process. | Disclosure of exploration and mining information by mining owners | Comprehensive utilization rate of gangue, waste rock and tailings = output of gangue, waste rock and tailings in current year / utilization amount of gangue, waste rock and tailings |

| Attribute | Weight |
|-----------|--------|
| Forward   | 0.25   |
| Backward  | 0.25   |
| Forward   | 0.25   |
| Environment friendly (Weight 0.30) | tailings in current year | tailings in current year |
|-----------------------------------|--------------------------|--------------------------|
| Waste gas emission of 10000 yuan mining output value (m³ / 10000 yuan) | The ratio of mining exhaust emissions to mining output value, reflecting the degree of environmental pollution caused by mining industry. | Ten thousand yuan of mining output value exhaust emissions = mining industrial exhaust emissions/extractive industry (mining) industrial sales output |
| Waste water discharge of 10000 yuan mining output value (10000 tons / 10000 yuan) | The ratio of mining wastewater discharge to mining output value, reflecting the degree of environmental pollution caused by mining industry. | Ten thousand yuan of mining output value wastewater discharge = mining industrial wastewater discharge/extractive industry (mining) industrial sales output |
| Smoke (dust) emission of 10000 yuan mining output value (10000 tons / 10000 yuan) | The ratio of the emission of smoke (dust) to the output value of mining industry, reflecting the degree of environmental pollution caused by mining industry. | Ten-thousand-yuan mining output value smoke (powder) dust emission = mining industry smoke (powder) dust emission/mining industry sales output value |
| Solid waste discharge of 10000 yuan mining output value (10000 tons / 10000 yuan) | The ratio of solid waste emissions to output value of mining industry, reflecting the degree of environmental pollution caused by mining industry. | Output of solid waste = (output of general industrial solid waste in mining + output of hazardous waste in mining)/ industrial sales output of extractive industry (mining) |
| Recovery and treatment rate of mine geological environment (%) | The proportion of the area of mine restoration and reconstruction in the total area of the damaged ecosystem, reflecting the effect of environmental protection and control in the process of mineral resources exploration and development. | Recovery and treatment rate of mine geological environment = the recovered and treated area of mine geological environment/the cumulative damaged area of mine geological environment |
| Green mine completion rate (%) | It reflects the overall situation of green mine construction | The proportion of the number of green mines included in the catalogue in the total number of mines |
| Number of demonstration areas to be established | The number of pre-construction mining green development demonstration zones in the province. | The number of green mining development demonstration zones set out in the provincial mineral resources planning |
| Proportion of large and medium mines (%) | The proportion of large and medium-sized mines in the total number of mines, reflecting the rationality of the scale and structure of mines. | Proportion of large and medium-sized mines = number of large and medium-sized mines/the number of all mines in the province |
| Proportion of clean energy production (%) | The proportion of clean energy mineral output energy value in | The proportion of clean energy in the total energy |
the total energy mineral output energy value, reflecting the environmental protection degree of mineral resources supply side.

production, including natural gas, hydropower and nuclear power, in the one-off energy production.

The local green mining development standard system has been established, scoring 25 points;
Developed the demonstration zone construction management system and related documents, and established the policy system, scoring 25 points for establishing a working system in which all departments promote and cooperate closely; Those that have built a regulatory system score 25. The total score is not more than 100 points.

Forward 0.33

The number of mining owners on the list of anomalies and on the list of serious violations.

Disclosure of exploration and mining information by mining owners

Number of abnormal directory and serious violation list = Number of mining owners included in the "abnormal Directory" and "serious violation list" in the province this year.

Backward 0.33

The degree of participation of the public in the production and construction of mines in the region and the degree of satisfaction with the improvement of the mining ecological environment and the sharing of profits.

Score according to relevant surveys

Degree of public participation: public satisfaction.

Forward 0.33

4. Calculation method

4.1. Index standardization

The specific indicators of inter provincial mining green development index are standardized by referring to the "fixed base range method" adopted in "2016 China Green Development Index Report", which can realize the omnidirectional comparability of indicators in horizontal (space) and vertical (time). The fixed base range method takes a specific year as the base year, and realizes the dimensionless standardization transformation of the basic index in the mathematical form similar to the standard range method, and its mathematical expression is $\frac{V_k^t - V_{k,\min}^t}{V_{k,\max}^t - V_{k,\min}^t}$, where $C_k^t$ is the dimensionless index value of the kth basic index calculated according to the fixed base range method in year t, $V_k^t$ is the
original measurement value of the basic index in year t, $V^0_{k,\text{max}}$ is the maximum value of all the original measurement values in t0 base year, and $V^0_{k,\text{min}}$ is the minimum value of all the original measurement values in t0 base year.

In the actual measurement, the year 2010 is used as the base year for calculation. If the dimensionless value of a basic index K in a province in 2015 is measured, the calculation formula of positive index can be specifically expressed as $C_{k}^{2015} = \frac{V_{k}^{2015} - V_{k,\text{min}}^{2010}}{V_{k,\text{max}}^{2010} - V_{k,\text{min}}^{2010}}$ (the dimensionless standardization method of positive index is (calculate annual index inter provincial value - 2010 index minimum value) / (2010 index maximum value - 2010 index minimum value), and reverse index dimensionless standardization method is (2010 index maximum - estimated annual index provincial value) / (2010 index maximum - 2010 index minimum value).

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4.2. Calculation of comprehensive results
The calculation method of inter provincial green development index of mining industry is that the values of each basic evaluation index are first treated with standardized numerical method, and then weighted and averaged step by step according to the weight determined by the research. The total index is calculated as follows:

$$B_{j}^{t} = \sum w_{jk} C_{jk}^{t}$$

$B_{j}^{t}$ represents the measurement value of the jth sub index in year t, $C_{jk}^{t}$ is the dimensionless index value of the kth index to which the sub index J belongs in year t according to the fixed base range method, $w_{jk}$ is the intra group weight of the index in the corresponding sub index J.

$$A^{t} = \sum w_{j} B_{j}^{t}$$

$A^{t}$ is the measure value of the total index in year t, $B_{j}^{t}$ represents the measurement value of the jth sub index in year t, and $w_{j}$ is the weight of the jth sub index. Measure value a of total index $A^{t}$ in year t is the sum of the measurement value of each sub index in year t multiplied by the weight.

5. Conclusion
Through many field research, in-depth study and repeated revision, the inter provincial green development index of mining industry is proposed in this paper, and the inter provincial mining green development index system including four sub-indexes is explored and constructed. This paper puts forward the calculation method, data source and data standardization method of each index. Delphi method and analytic hierarchy process are used to determine the weight of specific index and sub index, and the calculation method of total index and sub index is proposed. The next step is to expand data sources through empirical analysis, and the index system and calculation model will be further improved. The research results will provide technical support for the scientific promotion of green development of mining industry.
Acknowledgments
This work was financially supported by Department budget project of Ministry of Natural Resources "Construction Organization Implementation of Green Mines and Green Mining Development Areas" (No. 121102000000160012).

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