Systematic Thinking of Promoting Shanxi Metallurgy Industry Transformation and Upgrading under Information Economy Background

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Abstract: With the rapid development of the Internet, the metallurgical industry structure has undergone important changes. The traditional metallurgical industry structure can no longer meet the needs of the ever-changing economic development. Information economy takes information as production factor, it makes the deep integration of modern information technology and traditional industry, promotes the effective docking of supply and demand in the market economy, reduces the consumption of material and energy, and realizes the harmonious development of man and nature to the greatest extent. This study constructs the green development index system of metallurgical industry from four aspects: economic benefit, resource consumption, environmental protection and scientific and technological innovation. The sample data are from China Economic Statistical Yearbook (2021) and Industrial Economic Statistical Yearbook (2021). The corresponding weights of different indicators in the index system are obtained through the Analytic Hierarchy Process, and the original data are constructed and standardized by TOPSIS. Finally, comprehensive ranking is carried out to determine the green development level of metallurgical industry in Shanxi Province. Explore the mode and path of sustainable economic development of metallurgical industry in Shanxi Province so as to realize transformation and upgrading.

Keywords: Information economy, Metallurgical industry, The pattern and path of economic sustainable development, Green development level, Industrial transformation and upgrading, AHP, TOPSIS analysis

1 Introduction

Green economy is a concept put forward by The British environmental economist in his book Blueprint of Green Economy. He believes that green economy is equivalent to sustainable development economy (Pearce 1989). As for the concept of green economy, the most authoritative one is proposed by foreign periodical in its report "Towards Green Economy": Green economy is an economy that improves human well-being and social equity and significantly reduces environmental risks and ecological scarcity [8]. Domestic scholar believes that green economy means the realization of green economy and green industrialization [9].

ICIDC 2022, June 17-19, Qingdao, People's Republic of China

DOI 10.4108/eai.17-6-2022.2322615

Another domestic scholar proposed that the main content and approach of green economy is to run green and ecological through the process and results of economic activities in order to achieve sustainable development [2]. As can be seen from the above literature, green economy, as a development model of harmonious coexistence between man and nature, has attracted great attention from people [1]. In the context of green economic development, social demand has also developed great changes, metallurgy industry through technological innovation, energy conservation and emission reduction measures, to green development has been an inevitable requirement for its own business development [3].

At present, the industrial development of Shanxi Province is facing the evolution from resource economy to decline period, and the next five to ten years will be the window period and critical period of transformation and development. Metallurgical industry, as an important advantage industry and pillar industry in Shanxi Province, plays a major supporting and driving role in promoting the economic development of Shanxi Province and even the region [5]. Shanxi needs a clear understanding of their own metallurgy industry green development level in the end [6]. Compared with other key metallurgical industries in China, what are the disadvantages? That's what we need to talk about.

At present, there are few researches on green development of metallurgical industry. According to the characteristics of metallurgical enterprises and green manufacturing technology, Domestic scholar constructed a comprehensive evaluation index system of green metallurgy from three aspects: economic benefit, resource consumption and environmental impact [10]. Another domestic scholar built an environmental management system for the green development of metallurgical enterprises from six aspects of environmental management organization, system, project environmental management, operation of environmental protection facilities, emergency management, matching and matching operation and control of environmental protection facilities [4]. Domestic scholar put forward suggestions for the green development of metallurgical enterprises from three aspects of green environmental management consciousness, environmental production technology and green environmental management system [7].

2 Construction of evaluation index system of green development level of metallurgical industry

The indicators selected in this study are based on the seven decision-making objectives of green metallurgical industry: time, quality, cost, resource consumption, energy consumption, pollution emission, and scientific and technological research and development, which are summarized into four aspects: economic benefit, resource consumption, environmental protection, and scientific and technological innovation based on expert opinions. Based on these four aspects, the evaluation system of green development level of metallurgical industry was constructed and 11 specific evaluation indexes were finally established

The final indicator system of green development level of metallurgical industry is shown in Table 1.

Table 1: Index system of green development level of metallurgical industry

Economic benefits	Gross domestic product
	The cost of production
Resource consumption	Available resource stock
	Raw material consumption
	Auxiliary material consumption
	Energy consumption
The environmental protection	The environmental protection
	Waste water discharge
	Solid waste discharge
	Environmental governance
Science and technology innovation	R & d spending

3 The empirical analysis

3.1 Evaluation Method

AHP (analytic hierarchy Process), is a subjective weight method, can do qualitative and quantitative analysis of the combination, make the determination of results more objective, enhance the credibility of the determination of results. TOPSIS (Approximate ideal solution) is a method to sort a finite number of evaluation objects according to their proximity to the ideal goal. It is a method to evaluate the relative advantages and disadvantages of existing objects, which has the advantages of reliability, intuition and authenticity. Therefore, this study organically combined AHP and TOPSIS method, comprehensively ranked the green development level of metallurgical industry in 16 provinces, and determined the green development level of metallurgical industry in Shanxi Province.

3.2 The Data Source

In this study, the top 30 metallurgical enterprises in China were selected from 16 provinces including Gansu, Shandong and Jiangsu. The sample data of this study are from China Economic Statistical Yearbook (2021) and Industrial Economic Statistical Yearbook (2021), and the statistical yearbook of each province in 2021 is used as a supplement to the indicator data.

3.3 AHP (Analytic Hierarchy Process)

First, the factors in the same position are compared with each other to build a matrix. Second, the Delphi method is used to select 13 from Lanzhou university of technology, Lanzhou university experts panel, important scores of each index, and will these scores after summarizing unceasingly changes, until see eye to eye, according to the members of the opinions, the index system is got by hierarchical analysis method of the corresponding weights are different.

The mutual comparison of the final scale definitions is shown in Table 2.

Table 2: Comparison of scale definitions.

Scale	Define scale
1	The importance values of factor I and factor J are the same
3	The importance values of factor I and factor J are slightly heavier
5	The importance value of factor I and factor J are heavier
7	The importance values of factor I and factor J are extremely heavy
9	Factor I and factor J are the most important
2, 4, 6, 8	In the middle of the two judgments
Reciprocal	Factor comparison, the last value is more important than the first value

Construct the comparison matrix as shown in the figure 1.

$$A = \begin{bmatrix} 1 & 2 & 1/5 & 3 \\ 1/2 & 1 & 1/6 & 2 \\ 5 & 6 & 1 & 7 \\ 1/3 & 1/2 & 1/7 & 1 \end{bmatrix} \qquad A1 = \begin{bmatrix} 1 & 5 \\ 1/5 & 1 \end{bmatrix}$$

$$A2 = \begin{bmatrix} 1 & 3 & 5 & 3 \\ 1/3 & 1 & 1 & 1 \\ 1/5 & 1 & 1 & 1/3 \\ 1/3 & 1 & 3 & 1 \end{bmatrix} \qquad A3 = \begin{bmatrix} 1 & 2 & 3 & 1/6 \\ 1/2 & 1 & 2 & 1/5 \\ 1/3 & 1/2 & 1 & 1/6 \\ 6 & 6 & 6 & 1 \end{bmatrix}$$

Figure 1: Comparison matrices.

The constructed judgment matrices all passed the consistency test (CR<0.1), the final weight values are shown in the table 3.

Table 3: Weight of index system.

Target layer	First indicators	Weight	Secondary indicators	Weight	Index attribute
Example text 1	Economic benefits A_1	0.180	GDP A_{11}	0.150	Quantitative
			Production cost A_{12}	0.024	Quantitative
	Resource consumption	0.111	Available resource stock A_{21}	0.058	Quantitative

	A_2		Raw material consumption A_{22}	0.016	Quantitative
			Auxiliary material consumption A_{23}	0.012	Quantitative
			Energy consumption A_{24}	0.023	Quantitative
	Environmental protection A_3	0.641	Waste gas pollution A_{31}	0.112	Quantitative
			Waste water pollution A_{32}	0.072	Quantitative
			Solid waste pollution A_{33}	0.046	Quantitative
			Treatment A_{34}	0.411	Quantitative
	Scientific and technological innovation A_4	0.068	R&D spending A_{41}	0.068	Quantitative

3.4 TOPSIS

Building Raw Data: According to the established level measurement index system and the index weight determination based on AHP, the decision matrix is established.

Data standardization Processing: Firstly, the quantitative variables are linearly transformed and standardized according to the different properties of the variables. Secondly, all variable data are weighted. Finally, the weighted standardized treatment results are obtained. The ideal solution of the optimal scheme consists of the maximum value of each evaluation index, namely (0.11, 0.007818, 0.000036, 0.012868, 0.010996, 0.020999, 0.052506, 0.034626, 0.04888, 0.143239, 0.018534). The negative ideal solution consists of the minimum value of each evaluation index, namely (0, 0.018, 0, 0.000008, 0.013305, 0.011, 0.020999, 0.106323, 0.07631, 0.041897, 0.02149).

According to the established index system of level determination and the index weight determination based on AHP, the final decision matrix is shown in Figure 2

Linear transformation	Output value	Production cost	Available resources Stock	Consumption of raw materials	Consumption of auxiliary materials	Energy consumption	Waste gas pollution	Waste water pollution	Solid waste waste pollution	Treatment	R&D investment
Gansu	0	0.018	0.000008	0.013305	0.011	0.020999	0.106323	0.07631	0.041897	0.02149	0
Hunan	0.014918	0.011154	0.000001	0.011695	0	0.021	0.119164	0.063709	0.038198	0.441518	0.017441
...	...	...	...	...	...	...	...	...	...	...	...
Shanxi	0.002846	0.01494	0.000078	0.00794	0.010999	0.021	0	0.064458	0.001394	0.359942	0.003234

Figure 2: Weighted normalized matrix.

Ranking: The distance formula of scheme I from the ideal solution is as follows:

$$d_i^* = \left[\sum_{j=1}^{n} (X_{ij} - X_j^*)^2\right]^{1/2}$$

$$X_j^* = \max_i \{X_{ij}\} \tag{1}$$

The distance formula of scheme I from the negative ideal solution is as follows:

$$d_i^0 = \left[\sum_{j=1}^{n} (X_{ij} - X_j^0)^2\right]^{1/2}$$

$$X_j^0 = \min_i \{X_{ij}\} \tag{2}$$

Relative proximity formula:

$$C_i = \frac{d_i^0}{d_i^0 + d_i^*} \tag{3}$$

It can obtain d_i^*, d_i^0 and relative proximity Ci of 16 provinces by calculation The value of Ci ranges from 0 to 1, and the closer to 1, the better. In this study, it means that the higher the green development level of metallurgical industry is.

The overall result of the final scheme proximity is shown in Table 4.

Table 4: Program proximity overall results.

Provinces	d_i^*	d_i^0	C_i	Ranking
Anhui	41.7928	38.1389	0.47714	1
Hunan	41.275112	37.5171	0.47615	2
Liaoning	38.876	34.386	0.4693	3
Inner Mongolia	38.158	33.614	0.46834	4
Shanxi	39.979268	34.836	0.46563	5
Guangdong	34.02662	27.63598	0.44818	6
Jiangsu	32.35857	25.4972	0.4407	7
Zhejiang	32.78407	25.41256	0.43667	8
Guangxi	32.6815	25.222	0.43559	9
Tianjin	31.6258	23.63653	0.42772	10
Shandong	31.59534	23.54961	0.42705	11
Gansu	31.721	23.642	0.427	12
Hebei	31.30313	23.31314	0.42685	13
Hubei	31.514	23.465	0.4268	14
Fujian	31.348	23.245	0.42579	15
Henan	32.1116	23.67152	0.42435	16

According to the results of comprehensive ranking, the green development level of metallurgical industry in Shanxi Province is in the middle and upper level among the 16 provinces.

Concrete Analysis of Green Development Level of Metallurgical Industry in Shanxi Province: In order to further analyze the problems existing in the green development level of metallurgical industry in Shanxi Province, this study calculates the distance D between each indicator and the ideal solution to obtain the difference degree between each indicator and the ideal solution in Shanxi Province. As can be seen from the table 5 below, Shanxi Province is superior to the optimal green scheme index in terms of production output value, raw material consumption, waste pollution emissions, solid waste pollution emissions and R&D investment. Production cost, available resource stock, auxiliary material consumption, energy consumption and wastewater pollution discharge are slightly lower than the optimal green scheme index; The gap between the governance situation and the optimal green scheme index is the biggest.

Table 5: Index proximity calculation table of Shanxi province.

	Shanxi province
Output value (ten thousand yuan)	0.107154
Production cost (ten thousand yuan)	-0.007122
Available resources Stock (ten thousand tons)	-0.000042
Consumption of raw materials (ten thousand tons)	0.004928

Consumption of auxiliary materials (ten million cubic meters)	-0.000003
Energy consumption (ten million kilowatt hours)	-0.000001
Waste gas pollution (ten million cubic meters)	0.052506
Waste water pollution (ten thousand tons)	-0.029832
Solid waste waste pollution (ten thousand tons)	0.047486
Treatment	-0.21673
R&D investment (ten thousand yuan)	0.0153

4 Research conclusion and development countermeasure

4.1 Research Conclusion

On the basis of fully considering the characteristics of metallurgical industry, this study constructed the evaluation index system of green development of metallurgical industry from four aspects of economic benefit, resource consumption, environmental protection and scientific and technological innovation. AHP was used to determine the weight of the index system, TOPSIS model was used to approximate the ideal value to calculate the positive and negative ideal solution and the closeness degree of each index, and 16 provinces were comprehensively ranked. From the comprehensive ranking results, among the 16 provinces, the green development level of metallurgical industry in Shanxi Province is 0.46563, ranking the fifth, 0.01151 away from the first place Anhui Province, the gap is small, and its green development level is in the middle and upper level. However, from the calculation results, there is still a certain gap between Shanxi Province and the national optimal level, mainly manifested in: first, the production cost needs to be optimized; Second, the effective use of resources is insufficient, and the awareness of environmental protection needs to be improved.

4.2 Development Countermeasure

We will encourage enterprises to increase investment in innovation and r&d to optimize production costs. The production value of Shanxi Province is better than the optimal index, while the production cost is lower than the optimal scheme cost. Therefore, Shanxi Province should try to reduce the production cost in the future development of green. The best measure to optimize the cost is to increase innovation research and development. By making inclusive policies, the metallurgical enterprises in the province are encouraged to increase research and development investment, accelerate the elimination of backward production capacity, optimize the production process, and save the production process and human and material costs. We should encourage the integrated development of metallurgical industry and emerging industries, and give play to the driving role of emerging industries in the transformation and development of metallurgical industry. It has set up a number of perfect school-enterprise scientific research platforms jointly with colleges and universities in the province and leading enterprises such as

TISCO to concentrate on promoting technological innovation. In order to improve the total output value of metallurgical industry in Shanxi Province in the future, increase the economic benefits of metallurgical industry.

We will improve the efficiency of resource utilization and pay attention to the treatment of waste, waste and pollution. Shanxi Province metallurgical raw material consumption, waste pollution, solid waste pollution emissions than green optimal scheme index, stock of available resources, auxiliary materials consumption, energy consumption, waste water pollution is slightly less than the optimal solution, and the governance situation of Shanxi Province in terms of governance obvious shortcomings, differ with the optimal solution. Therefore, Shanxi Province should pay attention to the effective utilization of metallurgical industry auxiliary material consumption (including: water, liquid, etc.) and energy consumption, strengthen the control of resource consumption, and ensure that the consumption of available resources does not exceed the red line. Promote the metallurgy industry and high and new technology, energy conservation and environmental protection technology, adhere to control consumption from the source, comprehensive measures to achieve regional coordination and joint governance, and ultimately achieve efficient, clean and green production. In addition, Shanxi Province should continue to increase investment in the treatment of "three wastes", promote the metallurgical industry recycling process, "three wastes" recovery and disposal, pollution source treatment and other projects, so that the metallurgical enterprises in the province in the green technology level into the forefront of the country.

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