Research on Hebei Province's Iron and Steel Industry Transformation from the Perspective of Low-Carbon Economy

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Abstract. With the gradual rise of a low-carbon economy, the continuous expansion of Hebei's steel industry and the extensive development of enterprises have brought about a series of serious environmental problems. In this context, the transformation of Hebei's steel industry is imperative. This article takes the perspective of low-carbon economy as an entry point to study the development of the iron and steel industry in Hebei Province. Based on the theory of low-carbon economy, by drawing on the research results of predecessors and searching for relevant industry data, it restores the development of the iron and steel industry in Hebei Province. The author builds an econometric model to analyze the reasons for the high energy consumption, high pollution, high emission and low benefit development characteristics of Hebei iron and steel industry, finds out the problems that hinder Hebei iron and steel industry from low-carbon transformation, and puts forward scientific suggestions for the development of Hebei iron and steel industry.

1. The introduction
Hebei Province, which is dominated by heavy industry, has caused a series of environmental problems due to the long-term extensive development model. The grim reality has made people gradually turn their attention to the feasibility of low-carbon economic development models, and hope to realize the sustainable development of the steel industry.

The current research on low-carbon economy by Chinese scholars focuses on the theoretical level, and there is no complete quantitative model and calculation standard for measuring the degree of low-carbon development and the impact of low-carbon indicators. By constructing an econometric model, this article will study the low-carbon transformation of the iron and steel industry and make its own contribution to the successful transformation of the iron and steel industry in Hebei Province.

2. Connotation of low-carbon transformation in the steel industry
Low-carbon transformation means that the steel industry needs to use more low-carbon technologies and equipment in the production process to reduce unit energy consumption and reduce greenhouse gas emissions. The primary issue of the current low-carbon transformation of the steel industry is how to transform the characteristics of the “three highs and one low” of the steel industry and gradually
transform it into the “three lows and one high” of “low energy consumption, low pollution, low emissions and high efficiency” industry.

3. Problems faced by Hebei Iron and Steel Industry

In recent years, the contradiction between energy demand and supply, and the contradiction between the supply of raw materials and resources in the iron and steel industry in Hebei has been intensifying day by day. The consumption of coal resources accounts for more than 80% of the resource consumption in Hebei [1]. At the same time, the resource consumption of Hebei's iron and steel industry accounts for more than 15% of the total resource consumption in Hebei, and the resource consumption of the steel industry is huge.

The iron and steel output of Hebei Province is mainly contributed by private enterprises. The annual production capacity of these private enterprises is below 6 million tons, with low product concentration, backward technology and equipment, and poor independent innovation capabilities. They just produced some pig iron and crude steel. High-carbon and low-value-added products [2].

4. Evaluation of low carbon economy of iron and steel industry in Hebei Province

4.1. Construction of carbon performance evaluation model

For enterprises, the fundamental goal of their low-carbon transformation and development is to improve future carbon economic benefits. The basic purpose of carbon performance evaluation is to achieve a win-win situation of carbon resource benefits, economic benefits and environmental benefits by stimulating carbon emission reduction and restraining carbon emissions [3].

This article from the perspective of material flow, according to the relationship between the ratio of carbon resource and value, by analysing the input resource inputs, resource consumption in the process of production and circulation, output products and carbon emissions and operating income and the relationship between the carbon yield, build based on carbon resource efficiency, economic benefit and environmental benefit performance evaluation of the integration of the carbon equation analysis method. The equation is as follows:

\[ CO_2 \text{ emissions} = \frac{\text{carbon resource input amount} \times \text{business revenue}}{\text{carbon resource input amount} \times \frac{\text{carbon revenue}}{\text{business revenue}} \times \frac{CO_2 \text{ emissions}}{\text{carbon revenue}}} \]  

\[ CO_2 = Ri \times Rp \times Vp \times Ce \]
In the formula, CO2 represents the carbon emission in a certain period; Ri represents the input amount of carbon resources in a certain period; Rp represents carbon resource efficiency; Vp represents carbon economic benefits; Ce represents carbon environmental benefit.

The above equation can be decomposed into different meanings, and the performance information it embodies is analysed as follows:

(1) Operating income/carbon resource input amount represents the operating income generated by each unit of carbon resource input, namely carbon resource benefit. It is of great practical significance to improve the efficiency of carbon resources under the situation of the increasing shortage of carbon resources in China. At present, the energy consumption of the steel industry in the world is still dominated by coal and electricity. It is particularly important to achieve low-carbon development, reduce carbon resource input and improve resource efficiency.

(2) Carbon income/operating income refers to the proportion of income generated by carbon in operating income, that is, the economic benefit generated by carbon input.

(3) CO2 emission/carbon benefit represents the amount of CO2 emission required to generate each unit of carbon benefit, that is, its environmental benefit is reflected through the impact of CO2 emission on carbon benefit. The smaller the ratio is, the higher the carbon environmental benefit is.

4.2. Application of carbon performance evaluation equation analysis method in iron and steel industry

Based on the carbon resource input, operating income, carbon revenue and CO2 emissions of Hebei iron and steel industry in 2017, the relative value of Hebei iron and steel economic indicators from 2018 to 2020 was calculated on this basis, and then its carbon performance was analysed.

| Table 1. Relative value table of Hebei iron and steel economic indicators | 2017 | 2018 | 2019 | 2020 |
|-----------------------------|------|------|------|------|
| Carbon resource input       | 100  | 102.230 | 102.537 | 111.662 |
| Operating income            | 100  | 108.670 | 137.033 | 153.340 |
| The carbon yield            | 100  | 401.910 | 1009.678 | 1334.795 |
| CO2 emissions               | 100  | 94.110  | 87.522  | 81.396  |

| Table 2. Carbon performance evaluation index table of Hebei iron and steel | 2017 | 2018 | 2019 | 2020 |
|-----------------------------|------|------|------|------|
| Carbon resource efficiency  | 1    | 1.0630 | 1.3364 | 1.3732 |
| Carbon Economic Benefits    | 1    | 3.6984 | 7.3681 | 8.7048 |
| Carbon Environmental Benefits| 1    | 0.2342 | 0.0867 | 0.0610 |

Figure 2. Trend chart of carbon performance evaluation index of Hebei iron and steel
As can be seen from Table 1 and Figure 2, from 2015 to 2018, the carbon economy, resources and environmental benefits all showed an increasing trend, among which the carbon economy benefits grew faster, while the carbon resources benefits grew gently or even stabilized. The above phenomena indicate that Hebei iron and steel industry pays more attention to economic benefits and pays less attention to the full utilization of carbon resources. However, enterprises can exchange higher income with less carbon input to improve the efficiency of carbon resources.

By deforming the carbon performance evaluation equation and shifting the input amount of carbon resources to the left side of the equation, the carbon emission efficiency of unit resource is:

\[
\frac{CO_2}{Rt} = Rp \times Vp \times Ce
\]  

(3)

From the carbon emission efficiency trend graph per unit of resource, we can clearly see the increasing carbon environmental benefits. In recent years, a series of environmental protection measures have had a positive impact [4].

4.3. Significance of carbon performance evaluation model

The carbon performance evaluation model provides a new idea for improving the carbon performance of enterprises: developing circular economy to reduce carbon resource input, actively participating in carbon trading to reduce carbon cost, and making carbon budget to control carbon emissions can effectively improve the carbon performance of enterprises and promote the low-carbon transformation and development of enterprises.

(1) The results show that the resource cycle increases → the carbon resource input decreases → the ratio of the operating income to the carbon resource input increases → the carbon resource benefit increases;

(2) The carbon economic benefit is reflected by carbon income/revenue: carbon resource input decreases → CO₂ emission decreases → carbon cost decreases → carbon income increases → carbon income/revenue ratio increases → carbon economic benefit increases;

(3) From the reaction of CO₂ emissions/ carbon benefits, it can be concluded that the resource cycle increases → the CO₂ emissions decrease → the ratio of CO₂ emissions/ carbon benefits decreases → the carbon environmental benefits increase.

5. Suggestions on the low-carbon transformation of Hebei iron and steel industry

Through the carbon performance evaluation model, we can conclude that carbon resource efficiency is the key to restricting the low-carbon transformation of Hebei's steel industry. We should actively optimize the energy structure of the steel industry to reduce carbon resource input from the source and participate in carbon trading to reduce carbon costs. Formulate carbon budgets to control carbon emissions and other measures to improve the carbon performance of enterprises, improve carbon resource efficiency, and promote the low-carbon transformation and development of Hebei's iron and steel industry. which is:
5.1. Energy structure adjustment
The issue of energy and resources is the key point of the long-term transformation and the starting point of the long-term optimization path. Hebei’s current steel companies must increase investment in research and development of low-carbon energy and zero-carbon energy if they want to achieve fundamental changes in the energy consumption structure. For example, using natural gas instead of coal and nuclear metallurgy. In certain areas, wind and solar energy can also be used to replace coal as an energy source for smelting steel. Through energy conversion to gradually reduce the amount of coal used to change the energy structure of Hebei’s iron and steel industry.

5.2. Promote carbon trading
Relying on market mechanisms to reduce greenhouse gas emissions is a consensus reached by the international community. As a market system, carbon emission rights trading has the fundamental purpose of using carbon price fluctuations to reduce carbon emission reduction costs. The accumulation of experience in 7 carbon emission trading pilots in my country, including Beijing, Tianjin, and Shanghai, has laid the foundation for my country to fully launch the national carbon trading market in the future, which will provide an open trading platform for Chinese enterprises to participate in carbon trading. In fact, whether it is super emission or emission reduction, the fluctuation of carbon prices can be used to reduce carbon costs.

5.3. Low-carbon management innovation
To develop a low-carbon economy, it is necessary to rely on a good management system as a guarantee for the low-carbon transformation of enterprises. Iron and steel enterprises should establish a sound environmental management system, formulate a carbon budget system, and integrate carbon emission reduction strategies into every aspect and every aspect. In the link, plan management tools and management systems for controlling carbon emission activities. Incorporate green management systems such as energy auditing system, energy performance appraisal, carbon forecasting, and carbon measurement into the existing management system.

5.4. Adjust the steel layout
With the continuous expansion of the city this year, many steel companies that were previously outside the city have now been surrounded by newly built cities. The transportation and emissions of raw materials and products of these companies have formed a contradiction with the development of local new cities. Therefore, we should start to adjust the industrial layout of Hebei Iron and Steel, formulate corresponding planning policies to gradually implement the relocation of iron and steel enterprises, and guide Hebei iron and steel enterprises to transfer to resource-concentrated areas and coastal ports, so as to reduce enterprise costs and increase Industry concentration is the goal of improving the market competitiveness of the iron and steel industry in Hebei Province.

6. Conclusion
The era of low-carbon economy has arrived. Hebei iron and steel industry should actively seize the opportunity, promote industrial upgrading, improve technological innovation, optimize the organizational structure, adjust the steel layout to solve the problems in the development, promote the transformation of Hebei from a big iron and steel province to a strong iron and steel province, and promote the steel industry to achieve sustainable development.

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