International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 5, September-October 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Evaluation and Analysis of Carbon Emission Efficiency of Logistics Industry in Beijing-Tianjin-Hebei Region

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ABSTRACT

As China's "Capital Economic Circle", the Beijing-Tianjin-Hebei region has an important strategic position. Carbon emission efficiency can be understood as the ratio of the unit of carbon emissions generated to the economic cost invested, and under normal conditions, carbon emission efficiency improvement means that the production cost is reduced while the carbon emission is kept unchanged or the existing production input base is maintained. Improving carbon efficiency is conducive to the sustainable development of the logistics industry. Based on the 2010-2020 panel data, this paper uses the emission coefficient method to calculate the carbon emissions of the logistics industry in the Beijing-Tianjin-Hebei region from 2010 to 2020, takes the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region as the evaluation index, constructs a super SBM model to measure the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region, and then evaluates and analyzes the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region. The results show that the overall carbon emission efficiency in the Beijing-Tianjin-Hebei region shows a slow upward trend, and there is more room for improvement, and finally according to the above conclusions, suggestions such as establishing green values, formulating reasonable policies and optimizing management systems are put forward.

KEYWORDS: *Carbon emission efficiency; Emission coefficient method; Super SBM model*

How to cite this paper: Yushou Han | Haochen Nong "Evaluation and Analysis of Carbon Emission Efficiency of Logistics Industry in Beijing-Tianjin-Hebei Region" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-5, October 2023, pp.648-652, URL: www.ijtsrd.com/papers/ijtsrd59980.pdf

IJTSRD59980

1. INTRODUCTION

As an important part of the national economy, the development of the logistics industry is closely related to China's economic growth. Since entering the 21st century, the overall scale of China's logistics industry has grown rapidly, the level of logistics services has been significantly improved, and the environment and conditions for development have been continuously improved. Through the energy consumption data of the logistics industry and the calculation of the energy conversion standard coal coefficient in the China Statistical Yearbook, the total energy consumption of China's logistics industry is increasing from 2010 to 2020, and with the further development of the logistics industry, the total energy consumption of the logistics industry will reach 413.09 million tons of standard coal by 2020, compared with the total energy consumption of the logistics industry in 2000 of 114.4671 million tons of standard coal, which increased 28%. In September 2020, China proposed the "Shuangtan" goal, advocating a green, environmentally friendly and low-carbon development mode. Beijing-Tianjin-Hebei is located in the heart of the Bohai Sea Rim in Northeast Asia, the largest and most dynamic region in northern China, as China's "capital economic circle", its geographical connection, personal affinity, regional integration, cultural vein, deep historical origin, suitable radius of exchange, can fully integrate with each other, coordinated development, is the best choice as a research area.

At present, there are three main methods for accounting carbon emissions: emission factor method, mass balance method, and measured method. The results of Liu Mingda [1] et al. show that compared with the mass balance method and the measured method, the emission factor method is simple, clear and easy to understand, with mature accounting formulas and activity data, and there are a large number of application examples in the emission factor database, which is not prone to systematic errors. The emission factor method is a carbon emission estimation method proposed by the Intergovernmental Panel on Climate Change (IPCC), which can be simply understood as adding an emission factor to energy consumption, and the emission factor is the coefficient corresponding to energy consumption. The emission factor method is the most widely applicable and widely used carbon accounting method, which is simple to operate and low cost. Therefore, we use the emission factor method for accounting. Du Jun [2] et al. combined the BBC efficiency model and fuzzy set qualitative comparative analysis method to study the low-carbon efficiency of the logistics industry and its diversified development path under different factor configurations. Song Yajing [3] et al. used the ultra-efficient DEA model to measure the carbon emission efficiency value in China's interprovincial carbon emission efficiency, compared with the traditional DEA model, the non-expected output SBM model not only avoids the deviation caused by radial and angular measurement, but also considers the influence of undesired output factors in the production process, which can better reflect the essence of efficiency evaluation. Wang Yuhong[4] et al. established a Super-SBM model to analyze the logistics efficiency of 11 provinces and cities in the Yangtze River Economic Belt in the past 10 years, and analyzed the evolution characteristics according to the spatial pattern by echelon. Based on previous research results, CCR and BCC models cannot measure all relaxation variables, so there are shortcomings in efficiency assessment, and the ADD model can start from the relaxation variable, but cannot accurately measure the efficiency level, which has great limitations in use. The ultra-efficient SBM model is an efficiency evaluation method based on data envelopment analysis, and its calculation results measure the efficiency level of the evaluated object through various indicators, which can provide valuable efficiency evaluation information for decision makers and help them better manage and optimize the operational performance of the evaluated object. Therefore, we used the ultra-efficient SBM model to evaluate the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region.

In this study, the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region is studied. In the study of carbon emission efficiency in the regional logistics industry, the study of carbon emission efficiency, input resource production, output economic benefits, and environmental pollution generated in the production process, that is, carbon emissions, are the basic elements for evaluating carbon emission efficiency. Li Yan and Sun Zhenqing[5] selected labor, material resources and financial resources in the study of the measurement of the operation efficiency of China's logistics industry and the analysis of its influencing factors under the constraint of carbon emissions, and the specific input-output indicators included the number of employees in the logistics industry, highway mileage, fixed asset investment in the logistics industry, postal outlets and added value of the logistics industry, and at the same time measured the carbon emission rate by taking carbon emissions as undesired output. Zhang Rui, Hu Yanyong, and Hao Xiaotong[6] In the study on the dynamic response of energy eco-efficiency and its influencing factors in China's logistics industry, a series of indicators such as the number of employees in the logistics industry, the investment in fixed assets in the logistics industry, the consumption of standard coal, the added value of the logistics industry, the comprehensive cargo turnover, carbon dioxide emissions, regional economic level, and urbanization process were selected to measure the carbon emission efficiency of the logistics industry, so as to study the energy ecological efficiency of the logistics industry. According to the selection of previous scholars, the input indicators and output indicators we finally selected are different.

The resources consumed in production, as well as the human, material and financial resources involved in production, are "inputs", and the economic benefits obtained are "expected outputs", and we will select carbon dioxide, which accounts for the highest proportion of greenhouse gases produced by energy consumption in the production process, as the "undesired output" for research.

According to the results of previous scholars' research, the indicators of investment are inseparable from the three aspects of "manpower, material resources and financial resources", in order to ensure the integrity of experimental data, our "manpower" is selected as the number of employees in the logistics industry from 2010 to 2020 (unit: 10,000 people), "material resources" is energy consumption (unit: 10,000 tons) and operating kilometers (unit: 10,000 kilometers), and "financial resources" is fixed asset investment (unit: 100 million yuan). In order to ensure the feasibility and credibility of experimental data, we have selected the added value of the logistics industry (unit: 100 million yuan) and comprehensive turnover (unit) as the expected output.

Table.1 Evaluation indicators

Category	Level 1 indicators	Level 2 indicators	Unit
Input indicators	Infrastructure elements	Operating kilometer mileage	10,000kilometers
		Energy consumption	Tons of tons
	Capital elements	Number of employees in the logistics industry	Ten thousand people
		Investment in fixed assets	Billion yuan
Output indicators	Expected output	Added value of logistics industry	Billion yuan
		Comprehensive turnover of logistics industry	
	Unexpected output	Carbon emissions	Tons of tons

2. Methods and model

2.1. Emission coefficient method

The emission coefficient method is to sum the product of various energy consumed in the production process and the corresponding emission factors, and then obtain the total carbon emission data of the process, and its basic formula is as follows:

$$CE=\sum_{i=1}^{n}(44/12)\times w_i\times P_i\times E_i \qquad (1)$$

w_i : the carbon content per unit calorific value of i th energy source; P_i : the average low calorific value of i th energy source, and is the consumption of the first energy source. 44 is the molecular weight of carbon dioxide and 12 is the molecular weight of carbon.

According to the energy consumption statistics in the China Energy Statistical Yearbook, the carbon emission of the corresponding region can be calculated by combining the carbon content per unit calorific value of various energy sources and the average low calorific value of energy and the formula (1).

2.2. Super-efficient SBM model

At present, scholars at home and abroad mainly use ***data envelopment analysis*** (DEA) and ***stochastic frontier analysis*** (SFA) in the research on energy ecological efficiency, but in order to avoid the subjectivity and uncertainty caused by setting complex assumptions and establishing specific production functions and constructing the distribution of technical inefficiency in the early application of SFA. And the problem of relaxation variables not considered by the DEA, some scholars have used SBM models to measure ecological energy efficiency [2]. Then, in practical applications, it is found that when there are multiple decision units that are valid at the same time, the SBM model cannot further compare and rank these decision units. In order to improve, a super SBM model is proposed, which can effectively solve this defect, so this paper will use the super SBM model to study the carbon emission efficiency in the Beijing-Tianjin-Hebei region.

The proportional reduction (increase) of input (output) in the traditional evaluation model is improved, and the relaxation variable is added, which solves the problem of the traditional evaluation model. The basic formula is shown in (2).

$$\min\rho^*=\frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{i0}}}{1+\frac{1}{q_1+q_2}\left(\sum_{r=1}^{q_1}\frac{s_r^g}{y_{r0}^g}+\sum_{r=1}^{q_2}\frac{s_r^u}{y_{r0}^u}\right)} \qquad (2)$$

$$s.t.\begin{cases} X\lambda+s^-=x_0 \\ Y^g\lambda-s^g=y_0^g \\ Y^u\lambda+s^u=y_0^u \\ s^-\geq 0,\lambda\geq 0 \\ s^u\geq 0,s^g\geq 0 \end{cases}$$

Among them: is the efficiency value, is the relaxation variable of input, expected output and non-expected output, respectively represents the input, expected output and undesired output vector, and represents the number of three indicators.

2.3. Variable selection

Through the ultra-efficient SBM model, the MAXDEA software is used to analyze the plate data of the Beijing-Tianjin-Hebei region, and the descriptive statistics of the data are shown in Table 2, and the standard deviation values in the table are relatively small compared to the average, indicating that the distribution of data is more concentrated and skewed, and the distribution of carbon emission panel data in the logistics industry is more concentrated in a period of time.

Table.2 Descriptive statistics for variables

The variable name	Unit	Maximum	Minimum	Mean	Standard deviation
Operating kilometer mileage	10,000 km	21.26	1.57	7.59	7.94
Energy consumption	Tons of tons	1388.31	332.91	840.62	312.85
Number of employees in the logistics industry	10,000 people	60.23	11.43	32.80	18.57
Investment in fixed assets	Billion yuan	2807.26	840.84	333.80	145.20
Added value of the logistics industry	Billion yuan	2890.6	570.4	1292.76	810.67
Comprehensive turnover of logistics industry		14957.29	988.02	6227.03	5341.93
Carbon emissions	Tons of tons	2807.26	840.84	1702.55	616.12

3. Measurement results and analysis

This paper uses MAXDEA software to select the relaxation variables of the undesired output of the super-efficient SBM model of the number of employees, energy consumption, mileage of operating kilometers, fixed asset investment, added value of the logistics industry, comprehensive turnover, and carbon emissions in the Beijing-Tianjin-Hebei region, and calculates the carbon emission efficiency of the Beijing-Tianjin-Hebei region and measures and compares the carbon emission efficiency of the logistics industry from 2010 to 2020. Therefore, this paper uses the year as the cross-section and sorts the data results into Table 3, which is conducive to analyzing the temporal changes of carbon emission efficiency in the logistics industry in the Beijing-Tianjin-Hebei region.

According to the results of Table 3, it can be seen that the difference in carbon emission efficiency values between Beijing, Hebei and Tianjin shows a trend of first rising, then decreasing, and finally rising. From the difference of 0.63 between Beijing and Tianjin in 2010 to the maximum difference between Beijing and Tianjin in 2011 of 0.69, the regional difference showed a downward trend, and fell to the difference between Beijing and Tianjin in 2017 of 0.32 and then showed an upward trend, rising to the difference of 0.6 between Beijing and Tianjin in 2020, and the emission efficiency of Beijing's logistics industry basically fluctuated around 0.49, far lower than the national average[7]. Hebei fluctuates around 0.9 and Tianjin fluctuates around 0.97, both of which belong to the first echelon, far higher than the national average, and belong to the high-efficiency zone (the average efficiency is above 0.9). From 2010 to 2020, it can be seen that the carbon emission efficiency of Beijing's logistics industry has been stable in the first place for many years, indicating that the implementation of local policies can effectively constrain carbon emissions, making Beijing's carbon emission efficiency the smallest, Hebei and Tianjin's carbon emission efficiency rankings are not divided, and Tianjin's carbon emission efficiency ranks third during 2010-2014 and 2019-2020, which needs to be paid attention to and reduce unnecessary emissions.

Table.3 2010-2020 comprehensive value of carbon emission efficiency of logistics industry in Beijing-Tianjin-Hebei region

Province	Beijing	Hebei	Tianjin
2010	0.39	0.72	1.02
2011	0.42	0.82	1.11
2012	0.41	0.86	1.00
2013	0.43	0.85	0.88
2014	0.46	0.88	0.88
2015	0.47	0.88	0.82
2016	0.50	0.86	0.84
2017	0.56	1.00	0.88
2018	0.61	1.01	1.00
2019	0.60	1.01	1.06
2020	0.53	1.06	1.13
mean value	0.49	0.90	0.97

According to Table 4, it can be seen that Beijing and Hebei show an upward trend, while Tianjin shows a downward trend and then an upward trend. From 2016 to 2020, the Beijing-Tianjin-Hebei region as a whole showed an upward trend, which was due to the rapid development of the logistics industry due to the clear proposal to reduce logistics costs and improve logistics efficiency during the "13th Five-Year Plan" period.

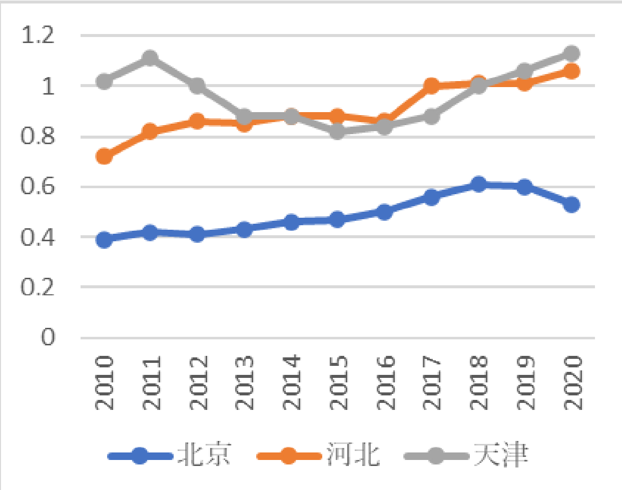

Table 4 Trends in Carbon Emission Efficiency of Logistics Industry in the Beijing Tianjin Hebei Region from 2010 to 2020

4. Conclusion

This paper uses the ultra-efficient SBM model to measure the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region from 2010 to 2020, and concludes that the carbon emission efficiency of the logistics industry in the Beijing-Tianjin-Hebei region is on the rise, and Beijing has great room for improvement in the low and medium efficiency areas. Second, the carbon emissions of the logistics industry in the Beijing-Tianjin-Hebei region have developed slowly. The above conclusions have important policy implications and are for reference only. First of all, we must establish green values, fully tap the green value of the logistics industry, and use new energy transportation tools. Secondly, it is necessary to increase investment in science and technology, and the Beijing-Tianjin-Hebei region should learn advanced science and technology, accelerate the construction and layout of logistics network node infrastructure, cultivate high-end logistics talents, adhere to innovation-driven development, promote logistics technology innovation and informatization construction, improve logistics efficiency and reduce carbon emissions. At present, the energy efficiency of the logistics industry is significantly lower than the national energy efficiency, in order to save energy and improve energy efficiency, the logistics industry needs to change the energy utilization mode and development model. Finally, we must strengthen government planning, formulate reasonable laws and regulations to restrict and adjust enterprises and regions, accelerate industrial structure adjustment, eliminate energy-consuming and high-polluting enterprises, and develop low-carbon and high-tech industries.

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