

Evaluation of Logistics Efficiency of Provinces and Cities Along the New Land-sea Passage Under the Constraint of Carbon Emission

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Abstract: In order to better improve the development of logistics industry in provinces and cities along the new land-sea channel under the background of "double carbon", and improve the efficiency of green logistics. Based on the logistics data of 13 key provinces and cities along the new land-Sea corridor from 2011 to 2020, this paper takes carbon dioxide emissions as unwanted output to build a green logistics efficiency evaluation system. Through the super-efficiency SBM model, the annual static green logistics efficiency of the logistics industry in each province and city is obtained, and the dynamic change of the regional green logistics efficiency compared with the previous year is measured by the Malmquist index model. The results show that: from 2011 to 2020, the green logistics efficiency of provinces and cities along the new land-Sea corridor showed a small trend of upward fluctuation, and the differences of logistics efficiency under the constraint of carbon emission were obvious, and the logistics efficiency of western provinces and cities had a large room for improvement. This paper puts forward suggestions to effectively improve the efficiency of green logistics, aiming to provide decision-making basis for the government to develop low-carbon economy in the logistics industry.

Keywords: Carbon emission, Logistics efficiency, SBM., Malmquist.

1. Introduction

The logistics industry is the main energy consumption sector of the tertiary industry in China, which is characterized by high cost, high energy consumption and low production efficiency. More than 90% of gasoline and more than 60% of diesel fuel in the country are consumed by the logistics industry [1]. In order to achieve energy conservation and emission reduction, "carbon peak" and "carbon neutral" were first included in the government work report of the National Two Sessions in 2021. Under the new economic development model, the low-carbon development quality of the logistics industry has attracted attention [2]. In August 2019, the release of the Overall Plan for the New Land and Sea Passage marks the official rise of the new land and sea passage area to the national strategy, which focuses on strengthening the construction of railway, highway and sea transportation channels and logistics facilities, and aims to improve the operation and logistics efficiency of the passage, and involves 14 provinces and cities, including Inner Mongolia, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. In recent years, with the deepening of cooperation in the new land-sea channel, the country and the provinces along the channel have continuously increased their investment in resources such as railways and highways, and the construction of the channel logistics system has made considerable progress on the whole; Since the launch of the "Southward Passage" project, improving the efficiency of logistics resource allocation and reducing the carbon emissions of logistics industry are of great significance to the development of green economy and the achievement of low-carbon goals in China. So, how to evaluate the logistics efficiency of provinces and cities along the new land-sea corridor under the constraint of carbon emissions? This is the content of this article.

Yan Yan revealed that there are significant differences in

regional logistics efficiency along the "the Belt and Road" in China [3]; Du Hui selected data samples from 30 provinces in China, set carbon emissions as unexpected output, combined with BBC efficiency model and fuzzy set qualitative comparative analysis (fsQCA) method, studied the low carbon efficiency of logistics industry and its diversified development path under different factor configurations [4]. Gong Ruifeng, Xue Jian and Liu Ruli measured and compared the logistics efficiency of 31 provinces in China from 2009 to 2018 through the three-stage DEA model [5]. At present, most of the research on logistics efficiency in China uses DEA model, which lacks the impact of environmental factors on the calculation results of logistics industry efficiency. Moreover, domestic scholars mostly study the logistics industry in the developed regions of the country and the east, and there are few discussions on the logistics efficiency of the new land-sea channel and the provinces and cities along it.

To sum up, it is proposed to study the logistics efficiency from the following two new perspectives. First, focus the research object on the provinces along the new land-sea channel. By exploring the logistics efficiency and its evolution trend of the provinces along the new land-sea channel, it will help to tap the potential of the connotative growth of the channel logistics and promote the high-quality coordinated development and high-level opening up of the western region. Second, it is proposed to build an input-output indicator system based on the carbon emissions of the logistics industry as an unexpected output. Taking the data of 13 provinces and cities in the new land-sea channel from 2011 to 2020 as an example, the Malmquist index and the super-efficiency SBM model are comprehensively used for analysis to explore the direction and intensity of green logistics efficiency.

2. Research Method

2.1. Super-efficiency SBM model

In view of the input-output relaxation and radial selection bias of traditional DEA, Tone proposed the super-efficiency SBM model to solve the problem that multiple evaluation results are 1 and cannot be compared. The formula of variable return to scale of the super-efficiency SBM model considering unexpected output is [6]:

$$\left\{ \begin{array}{l} \rho^* = \min \frac{\frac{1}{q} \sum_{i=1}^q \bar{x}_{ik}}{u_1 + u_2 \left(\sum_{r=1}^{u_1} \frac{y_r^g}{y_{rk}^g} + \sum_{l=1}^{u_2} \frac{\bar{y}_{lk}^b}{y_{lk}^b} \right)} \\ s.t. \\ \bar{x} \geq \sum_{j=1, \neq k}^n \lambda_j x_{ij} \\ \bar{y}^g \leq \sum_{j=1, \neq k}^n \lambda_j y_r^g \\ \bar{y}^b \geq \sum_{j=1, \neq k}^n \lambda_j y_l^b \\ \bar{x} \geq x_b \\ \bar{y}^g \geq y_k^g \\ \bar{y}^b \geq y_k^b \\ \sum_{j=1, \neq k}^n \lambda_j = 1 \\ \lambda_j \geq 0, \\ i = 1, 2, \dots, q; j = 1, 2, \dots, n \\ r = 1, 2, \dots, u_1; l = 1, 2, \dots, u_2 \end{array} \right. \quad (2)$$

Where: ρ^* is the target efficiency value; n is the number of decision-making units; q input quantity for DMU; u_1 is expected output; u_2 is not expected output; x_i , y_r^g , y_l^b elements in the corresponding input matrix, expected output

matrix and unexpected output matrix; λ_j is the weight vector; "k" is the variable is the evaluated unit; $(\bar{x}, \bar{y}^g, \bar{y}^b)$ The reference point of K the decision variable to eliminate the kth decision unit.

2.2. Malmquist index method

Malmquist index is a dynamic analysis tool, which is a method to measure total factor productivity based on DEA efficiency analysis method. Total factor productivity is obtained by comparing the current period with the previous period or base period [8]. Malmquist calculation formula is:

$$Tfpch = \left[\frac{D^t(x_{t+1}, y_{t+1})}{D^t(x_t, y_t)} \right] \times \left[\frac{D^t(x_{t+1}, y_{t+1})}{D^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D^t(x_t, y_t)}{D^{t+1}(x_t, y_t)} \right]^{\frac{1}{2}} \quad (1)$$

Where: $Tfpch$ is total factor productivity; D^t , D^{t+1} distance function of t period and $t+1$ period respectively; x_t , x_{t+1} respectively represents the input of the t and $t+1$ phases; y_t , y_{t+1} is the output of the t and $t+1$ periods; If $Tfpch > 1$ indicates the increase of total factor productivity.

3. Evaluation Indicators and Data

3.1. Input-output indicators

Based on the input-output perspective, the efficiency of logistics industry is defined as the ratio between the input and actual output of economic factors in logistics production activities. According to the scientific, unified and accessible data, the input-output evaluation index system of logistics industry under the constraint of carbon emissions is constructed.

Table 1. Input-output index of logistics efficiency of new land-sea channel under carbon emission constraints

target	Source of indicators	Measurement index
Input indicators	Capital investment	X1: Fixed assets investment in logistics industry, 100 million yuan
	Labor input	X2: Logistics practitioners, people
	Energy input	X3: Energy consumption of logistics industry, 10000 tons of standard coal
	Infrastructure investment	X4: Total comprehensive mileage of transportation line, km
Output indicators	Expected output	Y1: Added value of logistics industry, 100 million yuan
		Y2: Freight volume, 10000 t
	Unexpected output	Y3: Cargo turnover, 100 million t · km
		Y4: Carbon emission of logistics industry, 10000 tons

3.2. Data sources

At present, there is no statistical category of "logistics industry" in China's statistical classification system, but it can be seen from the Statistical Yearbook of China's Tertiary Industry that the logistics industry accounts for more than 83% of the share of transportation, warehousing and postal services in the Journal of Economic Management Science. Therefore, this paper uses transportation, warehousing and postal services to represent the logistics industry. The above indicators are selected from the data of 13 provinces and cities along China's new land-sea channel from 2011 to 2020 (Tibet was omitted due to the lack of data). The basic data are from

China Statistical Yearbook and China Energy Statistical Yearbook released by the National Bureau of Statistics.

3.3. Data handling

For the energy input in the above indicators, raw coal, gasoline, kerosene, diesel, fuel oil, natural gas, heat and electricity are selected as the main fuels consumed in the logistics industry, and each fuel is converted into standard coal by referring to the reference calorific value of energy and the conversion coefficient of standard coal in the China Energy Statistical Yearbook (Table 2).

Table 2. Conversion coefficient of standard coal for 8 kinds of energy

Type of energy	Conversion factor (kgce/kg)
raw coal	0.7143
gasoline	1.4714
kerosene	1.4714
diesel oil	1.4571
fuel oil	1.4286
natural gas	1.3300kgce/m ²
heating power	0.03412kgce/MJ
electric power	0.1229kgce/kW.h

The calculation formula is as follows (3).

$$E = \sum_i^n C_i \times e_i \quad (3)$$

Table 3. 8 Energy sources CO_2 emission coefficient

Type of energy	raw coal	gasoline	kerosene	diesel oil	fuel oil	natural gas	heating power	electric power
Carbon content per unit calorific value (t C/TJ)	26.37	18.9	19.5	20.2	21.1	15.3	-	-
Average low calorific value (kJ/kg, kJ/m ²)	200908	43070	43070	42652	41816	38931	-	-
Carbon oxidation rate	0.94	0.98	0.98	0.98	0.98	0.99	-	-
CO_2 Emission coefficient (kg CO_2 /kg)	1.9003	2.9251	3.0179	3.0959	3.1705	2.1622 (kg CO_2 /m ²)	9.46(t C/trillion J)	10069 (t C/a hundred million kW.h)

The emission formula of logistics CO_2 industry (4) is as follows:

$$CO_2 = \sum_i^n C = \sum_i^n E_i \times \theta_i = \sum_i^n E_i \times \sum_{i=1}^n W_i \times P_i \times F_i \times \left(\frac{44}{12}\right) \quad (4)$$

Among them, θ_i indicates the carbon emission coefficient of the i th energy; W_i carbon content per unit calorific value of energy; P_i is the average low calorific value of energy; F_i indicates carbon oxidation rate; $44/12$ denotes CO_2 molecular weight. C_i indicates the carbon emission of the i th energy; E_i indicates the i th energy consumption.

4. Empirical Analysis

4.1. Super-efficiency SBM analysis

(1) Overall technical efficiency analysis

Table 4. Overall efficiency level of the new land-sea channel in the west under the constraint of carbon emissions

	2011	2012	2013	2014	2016	2017	2018	2019	2020	Average
TE	0.629	0.637	0.637	0.696	0.643	0.645	0.654	0.719	0.720	0.661
PTE	1.005	1.032	1.016	0.934	0.882	0.841	0.885	0.877	0.890	0.928
SE	0.646	0.648	0.683	0.801	0.799	0.822	0.810	0.882	0.884	0.774

The average technical efficiency of the logistics industry in the provinces and cities along the western land-sea new corridor was only 0.661 under the constraints of carbon

emissions from 2011 to 2020, and the actual output level only reached 66.1% of the potential level, indicating that the technical efficiency of the logistics industry in the provinces

Among them, C_i is the energy conversion coefficient of the i th energy source, e_i is the consumption of the i th energy, $i=1,2, \dots, 8$.
As for carbon emissions, no statistical agency has directly provided statistical data, but it can be calculated by various estimation methods. In this paper, the emission of logistics industry is selected as the indicator of carbon emissions of logistics industry CO_2 . The eight energy sources mentioned CO_2 above are the basic data for the calculation of carbon emissions. The calculation of carbon dioxide emissions is based on the estimation of IPCC (2006) and calculated by the carbon emission coefficient method (Table 3) [10].

The SBM model belongs to the static efficiency evaluation for the analysis of DMUs, which reflects the input-output conversion efficiency of the research object during the research period. Based on the super efficiency SBM model and the original data of the logistics industry's fixed assets investment, logistics industry employees, logistics industry's energy consumption, total mileage of transportation routes, logistics industry's added value, freight volume, cargo turnover and carbon emissions of the logistics industry in the 13 key provinces and cities along the new Lu Hai channel from 2011 to 2020, this paper calculates the green logistics efficiency of the provinces and cities along the new Lu Hai channel from 2011 to 2020, The overall logistics efficiency of the new land-sea channel under the constraint of carbon emissions is obtained by using the MaxDEA tool, as shown in Table 4.

emissions from 2011 to 2020, and the actual output level only reached 66.1% of the potential level, indicating that the technical efficiency of the logistics industry in the provinces

and cities along the western land-sea new corridor is low, and the input-output structure is not reasonable enough, which needs further optimization. At the same time, this also confirms the research of the scholar Tian Gang to a certain extent. The efficiency level of China's logistics industry is low. From the perspective of time series, it is found that under the constraints of carbon emissions, the logistics industry of provinces and cities along the new land and sea channel in the west shows a fluctuating upward trend in both technical efficiency and scale efficiency, which indicates that the overall development momentum of the logistics industry along the the Belt and Road is good.

It can be seen from Table 5 that the technical efficiency of the logistics industry in the provinces and cities along the western land-sea new corridor under the constraint of carbon emissions increased year by year in 2011-2014, decreased briefly in 2014-2015, and warmed up after 2015, which is related to the fact that the Chinese government began to attach great importance to low-carbon development in 2015. Low-carbon economy has been put on the agenda of the government. Governments at all levels have actively responded to the central government's low-carbon economy

policy, and the logistics industry has begun to take the path of low-carbon development and green development. Moreover, the technical efficiency and the scale efficiency are almost the same, and the change trend is basically the same. The pure technical efficiency level is relatively high, hovering around 0.928, but the pure technical efficiency has been decreasing year by year. Therefore, the low level of the technical efficiency of the logistics industry in the provinces and cities along the new land and sea corridor in the western region under the constraint of carbon emissions is mainly due to the decline of the pure technical efficiency year by year, so it is necessary to actively introduce advanced management systems, specialized technologies and talents, Ensure the maximum use of resources.

(2) Analysis of individual technical efficiency

① Technical efficiency analysis

Technical efficiency reflects the proportion of the actual output of the logistics industry to the maximum potential output at the current level. It is a comprehensive measurement and evaluation of the resource allocation capacity, resource utilization efficiency and other capabilities of the decision-making unit.

Table 5. Calculation results of green logistics technical efficiency of provinces and cities along the new land-sea corridor from 2011 to 2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average	Sort
Guangxi	0.568	0.597	1.017	1.002	0.719	0.727	1.011	1.016	1.024	1.033	0.871	4
Hainan	1.108	1.091	0.404	1.001	0.496	0.415	0.351	0.365	1.029	1.167	0.743	6
Chongqing	0.582	0.505	0.491	0.566	0.510	0.462	0.421	0.466	0.490	0.497	0.499	7
Sichuan	0.342	0.343	0.422	0.391	0.430	0.298	0.265	0.270	0.281	0.272	0.331	9
Guizhou	0.292	0.299	0.377	0.396	0.362	0.311	0.332	0.320	0.248	0.242	0.318	11
Yunnan	0.222	0.255	0.345	0.307	0.331	0.271	0.246	0.240	0.206	0.200	0.262	13
Shanxi	0.459	0.514	0.613	0.724	0.713	1.026	1.014	1.001	1.009	1.069	0.814	5
Gansu	0.531	0.539	0.552	0.481	0.499	0.455	0.459	0.455	0.490	0.481	0.494	8
Qinghai	0.340	0.318	0.316	0.332	0.332	0.292	0.248	0.230	0.216	0.232	0.286	12
Ningxia	1.492	1.518	1.353	1.179	1.176	1.064	0.742	0.656	1.049	1.063	1.129	2
Xinjiang	0.310	0.321	0.361	0.386	0.348	0.333	0.271	0.355	0.335	0.274	0.329	10
Neimenggu	0.725	0.667	0.657	0.737	0.738	1.074	1.210	1.334	1.152	1.090	0.938	3
Guangdong	1.202	1.314	1.370	1.547	1.569	1.635	1.810	1.798	1.814	1.742	1.580	1
Average	0.629	0.637	0.637	0.696	0.633	0.643	0.645	0.654	0.719	0.720	0.661	-

Table 5 reports the efficiency level of green logistics in provinces and cities along the new land-sea corridor from 2011 to 2020. ① On the whole, from 2011 to 2020, the green logistics efficiency of provinces and cities along the new land-sea channel showed a slight fluctuation and rising trend, with an average value of 0.661, which is at the middle level. ② From the perspective of regions, the efficiency value of green logistics in Guangdong and Ningxia is greater than 1 during the measurement period, and the efficiency value of green logistics in Guangxi, Hainan, Shaanxi and Inner Mongolia is also greater than 1 during the measurement period, indicating that the level of logistics development in these regions is high and the input and output are reasonable; In addition, there are fluctuations of different degrees in other regions, indicating that the development of logistics industry in these regions is not stable enough and there is great room for improvement. The average value of logistics efficiency of provinces and cities along the new land-sea corridor from 2011 to 2020 is shown in Figure 1, of which Guangdong and Ningxia have the highest average efficiency values, 1.580 and 1.129 respectively; The average efficiency of Yunnan Province is

the lowest, only 0.262.

Although in recent years, with the policy development of the new land-sea channel, the western logistics industry has developed rapidly and made great achievements, its overall logistics efficiency level is still not high enough, and there is still some room for improvement with the frontier. The green logistics efficiency of the provinces and cities along the new land-sea channel still has great potential. Considering that the SBM measurement results are "relative efficiency", the measurement results only measure the relative level of logistics efficiency of provinces and cities along the new land-sea corridor. If other cities and cities in China are included in the sample, the efficiency measurement results may be different.

The inter-annual changes of logistics efficiency of provinces and cities along the new land-sea corridor under the constraints of carbon emissions from 2011 to 2020 are shown in Table 5. ① From the perspective of the whole region, the logistics efficiency of the provinces and cities along the new land-sea corridor has a slow fluctuating upward trend, and the

green logistics efficiency in 2020 has increased compared with the efficiency value of 0.629 in 2011. ② From the perspective of each city, the logistics industry in Guangdong Province has developed steadily in the past few years, basically maintaining a small upward trend and a small fluctuation, and basically tending to be stable; The logistics efficiency of Qinghai and Yunnan has a small change and a downward trend, ranking the lowest two among the 13 provinces.

② Pure technical efficiency analysis

Pure technical efficiency is the efficiency brought by the system and management level; It is to consider whether the

provinces and cities can achieve the maximum output level under the existing level of scientific and technological input from the perspective of technology and economy. Pure technical efficiency can represent the effective utilization rate of inputs, and the pure technical efficiency is greater than 1, indicating that the existing inputs have been fully utilized without considering the impact of scale factors; The pure technical efficiency is less than 1, which indicates that the existing investment has not been effectively utilized. It is necessary to improve production technology, strengthen organizational training and introduce high-quality talents to improve management level.

Table 6. The pure technical efficiency value and ranking of provinces and cities along the new land-sea channel from 2011 to 2020 under the constraint of carbon emissions

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average	Sort
Guangxi	1.061	1.123	1.122	1.033	1.022	1.019	1.012	1.018	1.047	1.056	1.051	5
Hainan	1.118	1.122	1.049	1.149	1.116	1.084	1.063	1.042	1.136	1.226	1.111	4
Chongqing	1.081	1.025	0.557	0.731	0.516	0.481	0.449	0.502	0.505	0.498	0.634	9
Sichuan	1.038	1.035	1.064	0.478	0.559	0.299	0.272	0.280	0.282	0.272	0.558	10
Guizhou	0.349	0.325	0.392	0.403	0.372	0.343	0.358	0.355	0.277	0.269	0.344	12
Yunnan	0.269	0.289	0.378	0.316	0.338	0.292	0.273	0.268	0.227	0.219	0.287	13
Shanxi	0.779	1.018	1.044	1.096	1.092	1.027	1.016	1.003	1.012	1.071	1.016	6
Gansu	1.090	1.067	1.048	0.516	0.527	0.467	0.517	0.549	0.511	0.483	0.677	8
Qinghai	1.118	1.148	1.139	1.094	1.081	1.017	0.429	0.399	0.318	0.324	0.807	7
Ningxia	2.315	2.400	2.503	2.119	2.076	2.027	2.078	2.429	2.481	2.561	2.299	1
Xinjiang	0.402	0.397	0.412	0.389	0.353	0.375	0.312	0.402	0.358	0.300	0.370	11
Neimenggu	1.080	1.005	0.792	1.016	1.043	1.086	1.214	1.348	1.271	1.310	1.117	3
Guangdong	1.366	1.457	1.709	1.797	1.861	1.954	1.935	1.912	1.974	1.977	1.794	2

It can be seen from Table 6 that during the study period, the pure technical efficiency of the logistics industry in Ningxia and Guangdong provinces was the best, and the pure technical efficiency was far greater than 1 in 10 years, which indicates that their logistics resources were reasonably utilized, the logistics management level was strong, the system construction was relatively perfect, and the degree of specialization was high. Among them, the pure technical efficiency of the logistics industry in 7 provinces is less than 1, and the pure technical efficiency of the logistics industry in Qinghai Province is between 0.8-1, which indicates that the management level of the logistics industry in this province is

good, and it is in a marginal invalid state. The pure technical efficiency of the logistics industry in the remaining provinces is low, so we need to take effective measures to strengthen the system construction and improve the management level, so that the pure technical efficiency can reach an effective state.

③ Scale efficiency analysis

Scale efficiency refers to the difference between the existing scale and the optimal scale under the premise of a certain system and management level. Scale efficiency is the production efficiency affected by scale factors, reflecting the gap between the actual scale and the optimal production scale.

Table 7. Scale efficiency value and ranking of provinces and cities along the new land-sea corridor from 2011 to 2020 under the constraint of carbon emissions

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average	Sort
Guangxi	0.535	0.532	0.907	0.970	0.703	0.713	0.999	0.998	0.978	0.978	0.831	6
Hainan	0.991	0.972	0.385	0.871	0.445	0.383	0.330	0.350	0.906	0.952	0.658	11
Chongqing	0.539	0.492	0.882	0.774	0.990	0.961	0.938	0.929	0.969	0.997	0.847	5
Sichuan	0.329	0.331	0.396	0.817	0.769	0.997	0.972	0.967	0.997	0.998	0.757	10
Guizhou	0.835	0.920	0.963	0.984	0.974	0.907	0.928	0.899	0.894	0.900	0.920	1
Yunnan	0.826	0.881	0.912	0.971	0.979	0.928	0.903	0.897	0.908	0.913	0.912	2
Shanxi	0.589	0.504	0.588	0.661	0.653	0.999	0.998	0.998	0.997	0.998	0.798	9
Gansu	0.488	0.505	0.527	0.933	0.947	0.975	0.888	0.829	0.959	0.997	0.805	8
Qinghai	0.305	0.277	0.278	0.304	0.307	0.287	0.578	0.575	0.680	0.715	0.430	13
Ningxia	0.645	0.632	0.541	0.557	0.566	0.525	0.357	0.270	0.423	0.415	0.493	12
Xinjiang	0.773	0.808	0.876	0.992	0.988	0.887	0.870	0.884	0.935	0.913	0.893	3
Neimenggu	0.671	0.663	0.829	0.725	0.708	0.989	0.997	0.990	0.907	0.832	0.831	6
Guangdong	0.880	0.902	0.801	0.861	0.843	0.837	0.935	0.940	0.919	0.881	0.880	4

According to Table 7, the scale efficiency of the logistics industry in Guizhou and Yunnan is the best among the 13 provinces and cities along the western land-sea new corridor

from 2011 to 2020, and the scale efficiency has always been between 0.8-1 in 10 years. The average scale efficiency of the logistics industry in Xinjiang, Guangdong, Chongqing, Inner

Mongolia, Guangxi and Gansu provinces is higher than 0.8. Although the scale efficiency of the logistics industry in the above provinces is invalid, the logistics scale remains at a high level, with a small gap from the optimal scale. The scale efficiency of the logistics industry in the remaining provinces is low, and further adjustment of the logistics industry investment is needed. Especially, the logistics industry in Qinghai and Ningxia provinces has not been fully developed, and the infrastructure construction is still weak, and the space for improvement is relatively large. Based on the analysis of the overall perspective, the scale efficiency of the logistics industry in the provinces and cities along the new land-sea corridor in the west has maintained a steady upward trend. In recent years, the provinces and cities along the western land-sea new channel have increased their policy and financial support for the logistics industry. The construction of logistics infrastructure has been gradually improved, and the logistics industry has entered the fast lane of development. However, the average scale efficiency of the logistics industry of the provinces and cities along the western land-sea new channel is 0.759, which has not yet reached the stage of scale efficiency. Therefore, in the future, the provinces and cities along the western land-sea new channel should not only expand the logistics scale, but also speed up the infrastructure construction. More importantly, we should improve efficiency.

4.2. Analysis of green logistics total factor productivity

The SBM model belongs to the static efficiency evaluation for the analysis of decision-making units, which reflects the input-output conversion efficiency of the research object

during the research period, while the Malmquist index is a land-to-land trend, which has consistently ranked first since 2013; The logistics efficiency values in Ningxia, Hainan, Guangxi, Shaanxi and Inner Mongolia fluctuate greatly and are all efficient; The logistics efficiency of Chongqing, Gansu, Sichuan, Xinjiang and Guizhou shows a first decline and then a dynamic analysis of the green logistics total factor productivity of provinces and cities along the Haixin Corridor. It only reflects the dynamic evolution of the green logistics efficiency of selected provinces and cities in each year.

To explore the change of green logistics efficiency over time, this paper uses the Malmquist index as a tool to conduct a more in-depth analysis of the total factor productivity of the logistics industry in 13 provinces and cities along the new land-sea corridor. According to the Malmquist index model and (Appendix 1) the original data of fixed assets investment in the logistics industry, logistics practitioners, energy consumption in the logistics industry, total mileage of transport routes, added value of the logistics industry, freight volume, cargo turnover and carbon emissions of the logistics industry in the 13 key provinces and cities along the new Lu Hai channel from 2011 to 2020, the total factor productivity of green logistics in the provinces and cities along the new Lu Hai channel is calculated using the MaxDEA tool, as shown in Table 8, The total factor productivity of green logistics in 13 provinces and cities from 2011 to 2020 is 1.034 under the constraint of carbon emissions. The technical efficiency and technological progress are 1.033 and 1.012 respectively, which shows that the efficiency of urban green logistics is driven by technical efficiency and technological progress.

Table 8. Total factor productivity of green logistics in provinces and cities along the new land-sea corridor under the constraint of carbon emissions

year	ML	PEC	TC	SEC	EC
2011-2012	1.167	1.016	1.027	0.993	1.149
2012-2013	0.858	1.088	1.004	1.112	0.802
2013-2014	1.123	1.137	0.944	1.266	0.978
2014-2015	0.886	0.934	0.983	0.957	0.950
2015-2016	1.021	0.977	0.932	1.056	1.058
2016-2017	1.084	0.969	0.944	1.071	1.122
2017-2018	1.160	1.024	1.049	0.978	1.136
2018-2019	0.989	1.153	0.953	1.193	0.887
2019-2020	1.016	0.994	0.992	1.002	1.022
mean value	1.034	1.033	0.981	1.070	1.012

In terms of time sequence, the total factor productivity fluctuation cycle of green logistics from 2011 to 2020 can be divided into three stages. From 2011 to 2012, the total factor productivity of green logistics showed an upward trend. After the financial crisis in 2008, thanks to the Logistics Industry Adjustment and Revitalization Plan issued by the State Council at that time, with the strong support of the country for the logistics industry, and the development of logistics technology and energy conservation and emission reduction technology, the total factor productivity of green logistics increased. From 2012 to 2014, the change trend of green logistics total factor productivity turned to decline again. At this stage, because enterprises have completed relatively easy energy conservation and emission reduction measures while promoting the development of low-carbon logistics, the cost of other measures is rising, and must make greater efforts and pay higher costs to continue to achieve low-carbon results, so total factor productivity at this stage showed a downward

trend. Since 2015, the total factor productivity of green logistics has shown a wave recovery trend, but the upward trend is relatively moderate. The main reason for the growth of total factor productivity at this stage is technological progress, especially with the promotion and use of new energy freight vehicles, the popularity of two-dimensional code technology, and the improvement of mobile internet and logistics information management level in recent years, the total factor productivity has shown an upward trend.

5. Conclusions and Suggestions

5.1. Conclusion

This paper uses Malmquist index and SBM model to empirically analyze the space-time evolution of the average green logistics efficiency of 13 provinces and cities along the new land-sea corridor, and analyzes the input and output of logistics resource factors in these provinces from the aspects

of logistics technology efficiency, technological progress and total factor productivity. Based on the analysis of Malmquist index, it is found that the growth rate of total factor productivity of logistics in the new land-sea corridor region also shows an upward trend under the constraint of carbon emissions, and mainly benefits from the continuous improvement of logistics technology innovation and application. Based on SBM model analysis, the data results show that the input-output ratio of provinces and cities with green logistics efficiency lower than 1 is not optimal in fixed assets investment, energy, infrastructure construction and other aspects of the logistics industry. At the same time, under the constraint of carbon emissions, the overall regional logistics efficiency is stable and rising, but the gap between provinces is still large, and there is great room for improvement of green logistics efficiency in provinces and cities along the line.

5.2. Propose

(1) Develop sophisticated technology and apply it to logistics scenarios. High-tech vigorously researched can promote the development of logistics industry, and ensure that these technologies can save resources and improve the utilization rate of resources, so as to ensure the development of technical efficiency and pure technical efficiency of logistics industry. In addition to popularizing unmanned sorting and unmanned vehicle transportation, we should attach importance to the use of cloud warehouse and internet, combine cloud warehouse and internet with low-carbon logistics, drive the work efficiency of the logistics industry, and improve the low-carbon operation of the logistics industry.

(2) Improve the energy structure and improve the utilization rate of resources. First of all, in the use of energy, we should reduce the consumption of high-polluting traditional energy such as coal and oil, and vigorously develop and utilize renewable and clean energy such as wind energy and solar energy. Secondly, according to the mode of transportation, it is suggested to digitize the mode of transportation and optimize the transportation route and mode to the greatest extent through transportation mode+Internet technology. At the same time, it is also necessary to develop multimodal transport to minimize energy waste and reduce carbon emissions during transportation.

(3) Strengthen the construction of logistics infrastructure and logistics parks. For provinces and cities with green logistics efficiency value lower than 1, the construction of logistics infrastructure and logistics parks should be strengthened. The realization of logistics modernization depends largely on the construction of infrastructure. To improve the efficiency of green logistics, relevant provinces and cities should fully consider their own logistics development conditions, facilities conditions, supply and demand levels and other objective conditions, and purposefully promote the connection and matching of various

logistics transport modes. The logistics parks have production Four major functions of freight, processing and trade .

(4) Promote the coordinated development of regional logistics. Under the background of dual economic cycle, provinces and cities along the new land-sea corridor should promote the cross-regional resource flow and linkage development of logistics. Cities with good development status should make full use of existing resources, actively communicate and cooperate with cities within or outside the province, carry out the linkage development of the logistics industry with each city, drive other cities to carry out the planning and development of the logistics industry, and build a cross-regional cooperation network, Support the development of third-party logistics information sharing platform, and integrate transport capacity and supply through mobile internet platform.

(5) Vigorously promote the concept of low carbon. At present, the rapid development of logistics industry brings not only high profits and high income, but also extensive damage to the environment. The government should guide logistics enterprises to establish a corporate culture of low carbon and low carbon development. Enterprises themselves should independently adopt low carbon methods in their work process. The government encourages such enterprises by setting certain standards and benchmarks for enterprises and giving corresponding policy preferences and economic incentives.

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