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Analysis of Total Factor Productivity of Logistics in Yellow River Basin Based on DEA-Malmquist Model

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Abstract: *The article uses the DEA Malmquist model to calculate the total factor productivity of logistics in 9 provinces of the Yellow River Basin from 2017 to 2021. It analyzes the changes in total factor productivity of logistics in the Yellow River Basin from a holistic and inter provincial perspective and decomposes it. Research has found that from 2017 to 2021, the total factor productivity index of each province in the Yellow River Basin was greater than 1, and logistics efficiency continued to improve. However, there is a problem of imbalanced and insufficient development. Some provinces should attach importance to technological improvement and allocate resources reasonably to improve comprehensive technological efficiency.*

Keywords: *Total factor productivity; Yellow River Basin*

1. Introduction

With the development of society and the progress of science and technology, logistics industry, as the "third source of profit", develops rapidly and occupies an important position in today's society. The development level of logistics industry and the effectiveness of logistics efficiency greatly affect the economic growth of a region. At present, improving logistics efficiency plays an extremely important role in promoting regional coordinated development. Combing through previous literature, it is found that, scholars mostly use DEA data envelopment method to measure logistics efficiency [1,2,3]. Under the background of economic "new normal", Chinese logistics industry has maintained a high growth rate and improved efficiency, which provides an important industrial support and guarantee for the national economy. The logistics industry growth rate is stable in various regions, but there are obvious differences in logistics efficiency. Aiming at the unbalanced development of logistics industry, this study uses the DEA-Malmquist model to analyze and evaluate the total factor productivity of logistics in nine provinces in the Yellow River Basin, and explores the evolution of logistics efficiency by comparing the provinces. Finally, it puts forward some optimization suggestions to solve the existing problems in logistics development.

2. Research methods, index selection and data sources

2.1 Research Methods

The total factor productivity distance function is used to measure the conversion of a set of inputs into a set of outputs. It aims to measure the relationship between the input used by a production unit and the output obtained. Based on the period, the expression formula of distance function is as follows:

$$D^t(x^t, y^t) = max\{\theta: (x^t/\theta, y^t) \in S^t\} \tag{1}$$

Where, x^t is the input unit of the function; $x^t \in R^s$; $y^t \in R^s$; S^t represents the optimal production surface composed of different efficient decision making units, namely, the technology frontier surface. The Malmquist productivity index in the t period based on the total factor technology level is:

$$M^t = \frac{D^t(x^t, y^t)}{D^t(x^{t+1}, y^{t+1})} \tag{2}$$

Based on the technical level of the t period, the change of technical efficiency from t period to $t+1$ period can be simplified as:

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$$M^{t+1} = \frac{D^{t+1}(x^t,y^t)}{D^{t+1}(x^{t+1},y^{t+1})} \tag{3}$$

Malmquist index can be decomposed into the change of technological progress and the change of efficiency, which can more intuitively explain the impact of the change of total factor productivity, expressed by the following formula:

$$M(x^{+1},y^{t+1},x^t,y^t) = \left[\frac{D^t(x^t,y^t)}{D^t(x^{t+1},y^{t+1})} \times \frac{D^{t+1}(x^t,y^t)}{D^{t+1}(x^{t+1},y^{t+1})}\right]^{\frac{1}{2}}$$

$$= \frac{D^t(x^t,y^t)}{D^{t+1}(x^{t+1},y^{t+1})} \times \left[\frac{D^{t+1}(x^t,y^t)}{D^t(x^{t+1},y^{t+1})} \times \frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right]^{\frac{1}{2}} \tag{4}$$

$$EC = \frac{D^t(x^t,y^t)}{D^{t+1}(x^{t+1},y^{t+1})}, TE = \left[\frac{D^{t+1}(x^t,y^t)}{D^t(x^{t+1},y^{t+1})} \times \frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)}\right]^{\frac{1}{2}} \tag{5}$$

In the study of this paper, EC represents the change of logistics technology efficiency, TE represents the change of logistics technology progress. Mis based on the Malmquist index of total factor production efficiency,and the change of M value represents the dynamic situation of total factor productivity or logistics efficiency in the period of t to $t+1$.

2.2 Index Selection

In Cobb-Douglas production function, input indicators generally include technology, labor and capital. However, it is difficult to obtain valuable information due to the difficulty in obtaining and quantifying relevant data of technical indicators, so it is chosen to exclude them. Therefore, labor, capital and logistics carrying capacity are selected as input indicators in this study.

2.2.1 Input index

(1) The number of logistics employees

In previous studies on logistics efficiency, the number of employees in transportation, warehousing and postal industries is often selected as the labor input index, so the number of employees in logistics is selected as the labor input index [4].

(2) Investment in fixed assets of logistics industry

Capital elements are indispensable resources for logistics operation, and fixed asset investment in logistics industry reflects the situation of capital operation. Therefore, fixed asset investment in logistics industry is taken as an input index [5].

(3) Logistics mileage

Logistics mileage reflects regional logistics carrying capacity. Due to geographical constraints, highway and railway transportation are the main modes of logistics transportation in the Yellow River Basin. Due to the prominent internal navigation mileage in Shandong Province, internal navigation mileage is added as the logistics mileage [6].

2.2.2 Output index

According to the studies of Qin Xiaohui [7] and Yuan Yakun [8], logistics output indicators should reflect the economic and logistics results produced in the production and circulation process, so freight turnover and the added value of transportation, warehousing and postal industry are selected as output indicators.

2.3 Data sources

In this chapter, relevant data of 9 provinces in the Yellow River Basin (Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan and Shandong) from 2017 to 2021 are collected as panel data as research samples, and DEAP2.1 software is used to measure the logistics efficiency of the Yellow River Basin. The data mainly come from China Statistical Yearbook, China Economic and Financial Research Database of Guotai 'an, logistics yearbook of each province and the website of statistics Bureau.

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3. Analysis of empirical results

DEAP 2.1 software was used to calculate the total factor productivity of logistics in the Yellow River Basin. The change of total factor productivity is analyzed from the perspective of whole and provincial.

3.1 Overall change of total factor productivity in the Yellow River Basin

Table 1: Overall change of total factor productivity in the Yellow River Basin

TIME	EC	TE	PTE	SE	M
2017-2018	1.009	1.034	1.012	0.997	1.043
2018-2019	1.069	1.133	0.995	1.075	1.212
2019-2020	1.055	1.015	1.043	1.012	1.07
2020-2021	0.977	1.332	0.97	1.007	1.302
mean	1.027	1.122	1.005	1.022	1.132

Table 2: Decomposition of total factor productivity in the Yellow River Basin

	EC	TE	PTE	SE	M
Qinghai	1.271	1.079	1.071	1.187	1.371
Szechwan	0.96	1.092	0.957	1.003	1.048
Gansu	0.914	1.186	0.923	0.99	1.084
Ningxia	1.05	1.118	1	1.05	1.174
Inner Mongolia	1	1.044	1	1	1.044
Shaanxi	1.071	1.143	1.102	0.972	1.223
Shanxi	1	1.015	1	1	1.015
Henan	1.015	1.04	1	1.015	1.056
Shandong	1	1.041	1	1	1.041
mean	1.027	1.122	1.005	1.022	1.132

Combined with Table 1 and Table 2, it can be seen that the mean value of total factor productivity in various periods of the Yellow River Basin is greater than 1, and the mean value of comprehensive technical efficiency and technological progress under the decomposition is also greater than 1, indicating that the logistics development level of the nine provinces in the Yellow River Basin is improving year by year, and the logistics efficiency is constantly improving.

3.2 Analysis of total factor productivity in the Yellow River Basin from the provincial perspective

Table 3: Analysis of total factor productivity in the Yellow River Basin from the provincial perspective

M	2017-2018	2018-2019	2019-2020	2020-2021
Qinghai	1.084	1.347	1.417	1.432
Szechwan	1.138	0.89	1.083	1.099
Gansu	0.955	1.265	1.025	1.115
Ningxia	1.005	0.951	1.051	1.892
Inner Mongolia	1	0.973	1.119	1.093
Shaanxi	1.047	1.309	1.294	1.262
Shanxi	1.007	1.139	0.901	1.028
Henan	1.103	1.096	0.898	1.144
Shandong	1.061	0.991	0.95	1.174
mean	1.044	1.107	1.082	1.249

Table 3 shows that the total factor productivity of the nine provinces in the Yellow River Basin during 2017-2021 is all greater than 1, but the balance of development needs to be improved. The average value of total factor productivity in Qinghai was the highest, reaching 1.371, while the average value of total factor productivity in Shanxi was the lowest, reaching 1.015, nearly 36 percentage points lower than that in Qinghai. Based on the analysis of Figure 1, it can be concluded that the higher total factor productivity of Qinghai is mainly due to its higher comprehensive technical efficiency and reasonable utilization and allocation of resources. The comprehensive technical efficiency of the other 8 provinces is low, so measures should be taken to continuously develop the comprehensive technical efficiency, so as to promote the continuous development of logistics level.

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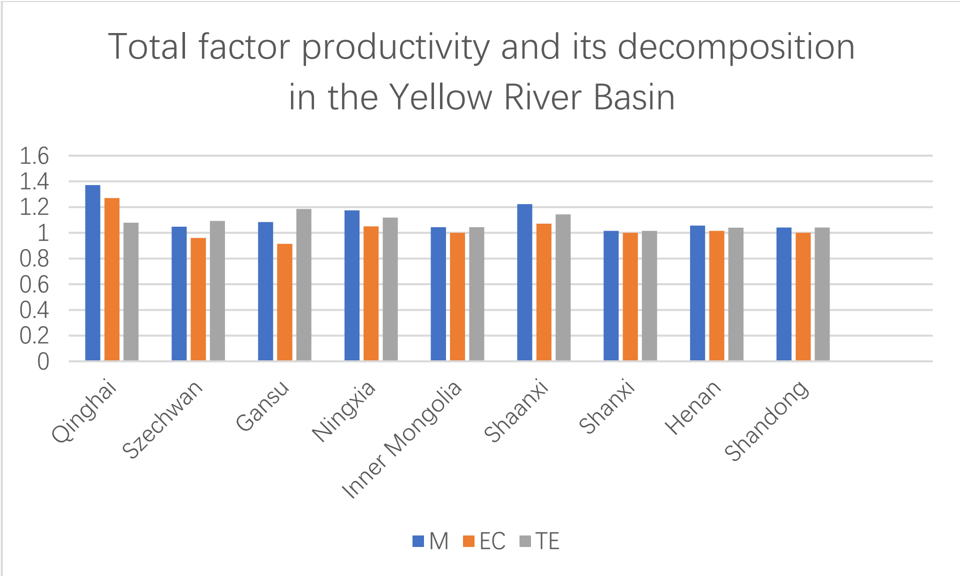

Figure 1: Analysis of total factor productivity in the Yellow River Basin from the provincial perspective

4. Countermeasure and suggestion

From the perspective of the whole and inter-province, the total factor productivity of the nine provinces in the Yellow River Basin is all greater than 1, indicating that the development level of logistics in each province is constantly improving. However, due to the large difference in total factor productivity index, it indicates that the development balance still needs to be improved. The main reason affecting the development of logistics efficiency in each province is the slow improvement of comprehensive technical efficiency. Therefore, the comprehensive technical efficiency index should be continuously improved through innovation and investment, so as to promote the continuous progress of the development level of logistics in the Yellow River Basin.

4.1 Rational allocation of resources and precise implementation of policies

Rational allocation of resources and precise implementation of logistics related policies are important ways to ensure high-quality development of the logistics industry. The government and enterprises should promote standardized management, improve service quality, formulate and improve logistics related industry standards, standardize market order, and improve the overall level of the industry. At the same time, establish a sound supervision mechanism and strengthen law enforcement. Strengthen the supervision of the logistics market, crack down on violations of laws and regulations, maintain a level playing field in the industry, and provide an environmental basis for the development of regional logistics.

4.2 Strengthen regional cooperation and promote coordinated development

The provinces in the Yellow River basin are closely connected and making progress together. In order to solve the unbalanced development of regional logistics, provinces in the Yellow River Basin should establish a regional logistics cooperation mechanism to promote the coordinated development of the industrial chain, supply chain and value chain, so as to realize resource sharing and complementary advantages. At the same time, it is necessary to strengthen information construction, improve information sharing and processing efficiency, and reduce logistics costs and risks by establishing regional logistics information platform. In addition, logistics network layout can be optimized through overall planning and reasonable allocation of logistics nodes, so as to improve logistics coverage capacity and shorten logistics timeliness.

4.3 Actively absorb talents and constantly innovate and develop

Strengthen the training of logistics professionals, and enhance the innovation ability of logistics technology. The lack of human resources leads to backward technology, and it is even necessary to introduce corresponding talents and technologies from foreign countries to maintain logistics operation, which greatly increases logistics operation costs and makes it difficult to improve logistics efficiency. In order to improve logistics efficiency and reduce costs, the government and enterprises need to introduce talents to further strengthen the internal management of logistics enterprises and optimize the organizational structure. At the same time, they need to strengthen innovation input, reduce logistics operation costs, optimize logistics routes, reduce resource waste in the logistics process, and constantly improve regional logistics efficiency.

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