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Characteristics and Renovation Project of Green Logistics System in Henan Province

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Abstract. Green development is at the core of the One Belt And One Road initiative and is also a requirement for high-quality economic development. This paper takes 18 cities in Henan province as the research object, analyzes the restricting factors of the development of green logistics based on system science theory, and then evaluates the characteristics of the green logistics system with the Super-SBM and Malmquist index considering the non-expected output, and finally explores the driving factors affecting the green logistics system based on the spatio-temporal analysis results. The results show that the calculation results considering the non-expected output are more consistent with the actual situation. The absolute difference of green logistics fluctuates, while the relative difference fluctuates. The decomposition index fluctuates greatly in western henan and is relatively stable in eastern henan. The evolution characteristics of green logistics in henan province have gone through three stages of decline, fluctuation and recovery, with different development drivers in each stage, mainly driven by logistics demand, policy and market technology.

1. Introduction

The 19th National Congress report puts forward the concept of “accelerating the construction of ecological civilization and building a beautiful China”, aiming at promoting green development and focusing on the development of “low-carbon economy”. The green concept has attracted much attention in various industries, and green total factor productivity has become an important indicator to measure industrial development. Henan Province is located in the Central Plains, with perfect transportation facilities and logistics network. The construction of “three districts and one group,” has accelerated the development of logistics industry in Henan Province. The deep integration of “The Belt and Road Initiative” has created a good environment for the development of logistics industry in Henan Province. After years of extensive growth, the logistics industry in Henan Province has formed a certain scale, but there is still a big gap with the developed countries in terms of resource allocation, technical efficiency and green concept: On the one hand, the logistics cost is too high. In 2017, the province's total social logistics cost to GDP ratio was 15.7%. Although it has made great progress, it still has a large development space compared with 10% in developed countries. On the other hand, as a third industry, the logistics industry cannot be ignored. Its energy consumption accounts for more than one-third of the tertiary industry. It is a veritable energy consumer, and the energy imbalance between regions is prominent. Therefore, improving the efficiency of the logistics industry and making the logistics industry develop healthily is the only way to promote the transformation of the economic development mode under the constraints of green total factor productivity.

In recent years, many scholars have conducted research on the total factor productivity of the logistics industry, mainly focusing on the following three aspects: On the one hand, it is based on the efficiency evaluation of the traditional logistics industry. For example, Yan and Rong [1] based on the input and output indicators of urban logistics, with the Malmquist non-parametric index model, empirical analysis of the total factor productivity of the logistics industry in 13 prefecture-level cities in Jiangsu Province; Hong and Yong [2] used the CCR model, BCC model and Malmquist index to measure the efficiency changes of Korean logistics providers; Ding et al. [3] used data envelopment analysis and exploratory data analysis methods to study the logistics development efficiency of the Yangtze River Delta, and discussed the evolution characteristics and mechanism of its spatiotemporal pattern. On the other hand, it is based on the research of industrial linkage development. For example, Zhen [4] used the ultra-efficient CCR-DEA model to evaluate the operational efficiency of the manufacturing and logistics industry linkage development system; Finally, the analysis of scientific development perspective, such as Jian et al. [5] carbon emissions as undesired output, using SBM model to measure the efficiency of logistics industry in 30 provinces (cities) of China, to study the spatial effects of China's regional logistics industry efficiency and its influencing factors; Bin et al. [6] used road noise as an undesired output and used the SBM model to evaluate the efficiency of the logistics industry from 2003 to 2011; Rong et al. [7]based on the perspective of green total factor productivity, using GML index method to empirically study the time series and spatial distribution of green total factor productivity growth in logistics industry ; Qing et al. [8] based on the Super-efficiency DEA model and ML index to study the spatial and temporal differentiation of total factor energy efficiency in the Yangtze River Economic Belt. In summary, the current analysis of the total factor productivity of the logistics industry is based on the DEA model, mainly for the purpose of improving efficiency, while ignoring the impact of improving the efficiency and undesired output on the environment. In view of this, this paper incorporates energy input and carbon dioxide (hereinafter collectively referred to as CO2) emissions into the indicator system, and uses the Super-SBM model and the Malmquist index to measure the green total factor productivity of the logistics industry in Henan Province, and portrays the evolution of different periods and regions. The process is characterized. On this basis, the evolution stage and motivation of the green total factor productivity of the logistics industry are analyzed. Finally, conclusions and suggestions are made to provide reference for the sustainable and healthy development of the logistics industry in Henan Province.

2. Research methods and data description

2.1. Research methods

2.1.1. Super-SBM model with undesired output

Tone [9] proposed a non-radial, non-angle SBM model based on the slack variable, which makes the efficiency value more accurate than the traditional measurement results. However, in real production, the expected output is accompanied by undesired output, such as waste discharge and bad debt loss. Considering only the expected output will make the measurement result "false high" and cannot reflect the true efficiency. To solve this problem, Tone [10] proposed an extended model based on SBM containing undesired outputs, which is expressed for a specific decision-making unit model (x_0, y^g, y_0^b) :

$$p^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_{i0}^-}{x_{i0}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{s_2}\frac{s_r^b}{y_{r0}^b}\right)}$$

$$s.t\begin{cases} x_0 = X\lambda + S^- \\ y^g = Y^g\lambda - S^g \\ y^b = Y^b\lambda + S^b \\ S^- \geq 0, S^g \geq 0, S^b \geq 0, \lambda \geq 0 \end{cases} \tag{1}$$

In formula (1), each DMU has m inputs, s_1 types of expected outputs are y^g, s_2 types of undesired outputs are y^b, and λ is a weight. And the objective function P is strictly decremented with respect to S^-, S^g and S^b, and when $0 \leq P \leq 1$, the decision unit is fully effective if and only if $S^- = S^g = S^b$.

Since the traditional measurement efficiency value is at most 1, the effective unit cannot be effectively compared. This requires the Super-efficient SBM model. Assuming that there are n decision-making units, each decision-making unit has m inputs (x), where $X = (x_1, x_2, \cdots x_n)$ $Y^g = (y_1^g, y_2^g, \cdots y_n^g)$ $Y^b = (y_1^b, y_2^b, \cdots y_n^b)$ the production possibility set is

$$P = \left\{x, y^g, y^b\right\} \left| x \leq X\lambda, y^g \leq Y^g \lambda, y^b \leq Y^b \lambda \right\}$$

in the case of variable scale returns, and the Super-SBM model of undesired output is:

$$\alpha^* = \min \frac{\frac{1}{m}\sum_{i=1}^{m}\frac{\bar{x}}{x_{ik}}}{\frac{1}{s_1+s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{rk}^g} + \sum_{r=1}^{s_2}\frac{s_r^b}{y_{rk}^b}\right)}$$

$$s.t\begin{cases} \sum_{j=1, j\neq k}^{n} x_{ij}\lambda_j - \bar{s_i} \leq x_{ik} \\ \sum_{j=1, j\neq k}^{n} y_{rj}\lambda_j + s_r^g \geq y_{rk}^g \\ \sum_{j=1}^{n} y_{tj}^b - s_t^{b^-} \leq y_{rk}^g \\ 1 - \frac{1}{r_1+r_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{rk}^g} + \sum_{r=1}^{s_2}\frac{s_r^b}{y_{rk}^b}\right) > 0 \\ s^-, s^b, s^g, \lambda > 0 \\ i = 1, 2, \text{n}m; r = 1, 2, \text{n}s; j = 1, 2, \text{n}n (j \neq k) \end{cases} \tag{2}$$

In order to make the results more accurate, this paper will select the Super-SBM model with undesired output to measure the green total factor productivity of logistics industry in Henan Province.

2.1.2. Malmquist index

The Super-SBM method can be used to evaluate the relative efficiency of the DMU, but it cannot find the specific factors that limit the efficiency. The ML index can not only measure the expected output that is conducive to economic development, such as GDP, but also measure the unexpected output, such as the environmental pollution and bad debt rate. Wait for undesired output. Therefore, continue to use the ML (Malmquist-Luenberger) index that considers the undesired output, namely:

$$\text{ML}_T^{T+1} = \left[\frac{1+\overrightarrow{D_0^t}(x^t, y^t, z^t; y^t, -z^t)}{1+\overrightarrow{D_0^t}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})} \times \frac{1+\overrightarrow{D_0^{t+1}}(x^t, y^t, z^t; y^t, -z^t)}{1+\overrightarrow{D_0^{t+1}}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})}\right] \tag{3}$$

The ML index can be decomposed into the Technology Progress Index (TECH) and the Technical Efficiency Index (EFFCH), namely:

$$TECH_T^{T+1} = [\frac{1+\overrightarrow{D_0^{t+1}}(x^t, y^t, z^t; y^t, -z^t)}{1+\overrightarrow{D_0^t}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})} \times \frac{1+\overrightarrow{D_0^{t+1}}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})}{1+\overrightarrow{D_0^{t+1}}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})}] \quad (4)$$

$$EFFCH_t^{t+1} = \frac{1+\overrightarrow{D_0^t}(x^t, y^t, z^t; y^t, -z^t)}{1+\overrightarrow{D_0^t}(x^{t+1}, y^{t+1}, z^{t+1}; y^{t+1}, -z^{t+1})} \quad (5)$$

In the above formula, it is the change index of green total factor productivity from t period to $t+1$ period, which is the change index of technological progress from t period $t+1$ period, and the change index of technical efficiency from t period to $t+1$ period. The greater than 1 respectively indicates the improvement of comprehensive efficiency, the improvement of technology and the improvement of technical efficiency; on the contrary, it indicates that the corresponding deterioration, that is, farther and farther from the target value.

2.2. Research Indicators and Data Processing

The whole process of logistics includes transportation, storage, loading and unloading, handling, packaging, distribution processing, distribution, information processing and other links. There are many links involved in the whole logistics process, and the statistics are not perfect, but due to transportation and warehousing. And the postal industry accounts for more than 85% of the added value of the logistics industry. Therefore, transportation, warehousing and postal services are selected to replace logistics-related data. As a parameter data of the logistics industry, the green total factor productivity evaluation index system of the logistics industry is constructed (Table 1).

Table 1. Green total factor productivity evaluation index system of logistics industry

Indicator type	Primary indicator	Secondary indicators	unit
Input indicator	Capital investment	Fixed assets investment in the logistics industry	One hundred million yuan
	Labor input	Labor quality	Person/year
	Energy input	Primary energy consumption in the logistics industry	10,000 tons of standard coal
Output indicator	Economic output	Logistics also increased	One hundred million yuan
	Scale output	Comprehensive turnover	100 million tons/km
	Undesired output	CO_2 emissions	10,000 tons

2.2.1. Input indicators

The fixed asset investment amount is reduced according to the price index to the nominal value, which is converted into the constant price in 2007 to measure the actual capital level of the industry; the quality of labor is obtained by multiplying the total number of employees in the industry by the number of years of education per capita. The energy input is the sum of the seven energy sources with the largest one-time energy consumption in the industry.

2.2.2. Expected Output Indicators

Expected output selects the added value of the logistics industry and the comprehensive turnover, which represent economic output and scale output, respectively. The added value of the logistics industry uses the value-added index of the tertiary industry to convert the nominal price into the constant price of the base period in 2007; The logistics industry turnover mainly considers three modes of transportation: railway, waterway and highway, and converts the passenger turnover and cargo turnover into a comprehensive turnover.

2.2.3. Undesired output indicators

The transportation process runs through the entire logistics process. The pollution in the whole logistics process mainly comes from the emission of CO2 during transportation. This paper separately counts the seven energy consumption consumptions of the logistics industry with the highest consumption, and according to the IPCC2006 carbon emissions calculation guide to calculate:

$$CO_2 = \sum_{i=1}^{7} CO_{2i} = \sum_{i=1}^{7} E_i \times NCV_i \times CEF_i \times COF_i \times \frac{44}{12} \tag{6}$$

In equation (6), the first energy consumption ($i = 1, 2, \cdots, 7$), NCV_i is the average low calorific value of each energy source, CEF_i is the carbon emission reference coefficient for each energy source, COF_i is the carbon oxidation factor, and 44 and 12 are CO_2 and Molecular weight of C. The data of the input-output indicators in this paper are derived from the total energy consumption of transportation, warehousing, and postal services and the added value of national economic accounts under the total energy consumption of the energy column industry in the “Henan Statistical Yearbook” (2007-2017). Calculate the energy consumption per unit of added value under the added value of transportation, warehousing and postal industry, and calculate the energy consumption of each city according to the added value of transportation, warehousing and postal services in each city multiplied by the energy consumption per unit of added value.

3. Analysis of empirical results

3.1. Comparative Analysis of Total Factor Productivity Measurement Methods in Logistics Industry

In order to intuitively reflect the impact of environmental constraints on total factor productivity, we use MAXDEA6.0 to calculate the data set of the finished panel. There are three kinds of measurement cases in this paper, which are: considering environmental constraints, namely (Super-SBM-Undesirable model with undesired output, Super-SBM model without considering environmental constraints, and traditional BCC model. The specific results are shown in Table 2, Table 3and Table 4.

It can be seen from the table that the average ML index of the total factor productivity of logistics industry in Henan Province considering environmental constraints in 2007-2017 is 0.9848, with an average decrease of 1.29%. The average technical efficiency index without considering environmental constraints is 0.9977, while the average value of the technological progress index is 0.9872, with an average decrease of 1.05%. The traditional BCC model has a high measured value, and the Super-SBM model estimates the intermediate value. The green total factor productivity measured by the Super-SBM model after considering the undesired output is lower than the other two. It can be seen that the results obtained without considering the environmental impact overestimate the actual production efficiency, which is consistent with the actual situation. Overall, the comparative analysis of the calculation methods further validates the rationality of the model.

Table 2. Green total factor productivity index of logistics industry

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
An yang	0.8969	1.0270	0.8003	0.9401	1.0047	1.0743	1.0239	1.0820	1.0169	1.0213
Hebi	0.9112	1.0123	0.8007	1.1871	1.0066	1.0512	1.0240	1.0366	1.0235	1.0211
Jiyuan	1.0317	1.0030	0.8002	0.7369	1.0068	0.7856	1.0240	1.0286	1.0204	1.0209
Jiaozuo	0.9453	1.0146	0.7990	0.9674	1.0069	1.0889	1.0409	1.0247	1.0150	1.0144
Kai feng	0.8394	0.9065	0.8596	0.7767	1.0063	1.0872	0.9624	1.0557	1.1447	1.0285
Luo yang	0.9003	1.0143	0.8841	0.8676	1.0055	0.7641	1.0243	1.0313	1.0452	1.0434
Luohe	0.8988	1.0241	0.7478	0.8509	1.0070	1.0824	1.0241	1.0251	1.0124	1.0092

Nan yang	0.8969	1.0135	0.9059	1.0068	1.0116	1.0474	1.0248	1.0467	1.0392	1.0322
Ping ding shan	0.8968	1.0146	0.8005	1.0412	1.0018	0.9973	1.0474	1.0292	1.0469	1.0446
Puyang	0.9118	1.0149	0.8658	1.0657	1.0061	1.0475	1.0370	1.0240	1.0167	1.0134
San men xia	0.9608	0.9194	0.8490	2.1606	1.0038	1.0468	0.9925	1.0501	1.0214	1.0308
Shang qiu	0.8972	1.0145	0.8004	1.1517	1.0046	1.0449	1.0241	1.0396	1.0571	1.0204
Xin xiang	0.9180	1.0084	0.8003	0.8085	1.0039	0.8970	1.0237	1.0380	1.0964	1.1117
Xin yang	0.9388	1.0145	0.8003	0.6797	1.0066	1.0478	1.0400	0.9830	1.0105	1.0093
Xu chang	0.9362	1.0134	0.8708	0.6426	1.0043	1.0866	1.0811	1.0279	1.0396	0.9982
Zheng zhou	0.9429	1.0087	0.8902	1.0563	1.0087	1.0182	0.8100	1.0252	1.0045	1.0150
Zhou kou	0.9075	1.0144	0.8003	0.9798	1.0060	1.0462	1.0239	1.0396	1.0351	1.0285
Zhu ma dian	0.9223	0.9639	0.8003	0.6977	1.0043	0.8815	1.0238	0.989	1.0432	1.0379

Table 3. Logistics industry technical efficiency index

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
An yang	1.0001	0.9999	1.0001	1	1	0.9998	1.0001	0.9856	0.9895	0.9886
Hebi	0.9997	0.9998	1.0004	1	0.9998	1.0002	0.9999	1.0001	0.9936	0.9997
Jiyuan	0.9998	1.0003	1	0.9999	1.0001	1	1	0.9964	0.9954	0.9964
Jiao zuo	0.9999	1.0001	1	1	0.9999	1	1.0001	0.9828	0.9849	0.9890
Kai feng	1	0.9999	1.0001	1	0.9999	1	1	1	1	1
Luo yang	0.9999	1.0001	1	1	1	1	1	1	1	1
Luohe	0.9998	1.0002	1	0.9999	1.0001	0.9999	1.0001	0.9800	0.9795	0.9763
Nan yang	1	1.0001	1	1	0.9999	0.9999	1.0002	0.9940	0.9939	0.9912
Ping ding shan	1	1	1	1	1	0.9999	1.0001	0.9955	0.9978	0.9975
Pu yang	0.9997	1.0002	0.9999	1	1	1	1.0001	0.9832	0.9831	0.9814
San men xia	1	1	1	1	1	1	1	1	1	1
Shang qiu	0.9999	1.0001	1.0002	0.9999	1	0.9998	1.0002	0.9943	0.9935	0.9922
Xin xiang	0.9999	1.0001	1	1	1	1	1	0.9933	0.996	0.9938
Xin yang	1	1	1.0001	1	0.9999	1	1.0002	0.9478	0.9788	0.9789

Xu chang	0.9999	1.0001	0.9999	1.0001	0.9999	1.0001	1	1	1	1
Zheng zhou	0.9999	1.0001	1	1	1	1	1	1	1	1
Zhou kou	1	0.9999	1.0001	0.9999	1	1.0001	1	0.9899	0.9909	0.9964
Zhu ma dian	0.9999	1.0001	1	1.0001	0.9999	0.9999	1.0002	0.9950	0.9956	0.9947

Table 4. Logistics industry technology progress index

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Any ang	0.8968	1.0271	0.8002	0.9402	1.0046	1.0745	1.0237	1.0978	1.0277	1.0331
Hebi	0.9114	1.0125	0.8003	1.1871	1.0068	1.0510	1.0241	1.0365	1.0302	1.0214
Ji yuan	1.0319	1.0027	0.8002	0.7370	1.0067	0.7856	1.0240	1.0323	1.0251	1.0246
Jiao zuo	0.9454	1.0145	0.7990	0.9674	1.0070	1.0889	1.0408	1.0426	1.0306	1.0257
Kai feng	0.8394	0.9065	0.8595	0.7767	1.0063	1.0872	0.9624	1.0557	1.1447	1.0285
Luo yang	0.9004	1.0143	0.8841	0.8676	1.0055	0.7641	1.0243	1.0313	1.0452	1.0434
Luo he	0.8989	1.0239	0.7478	0.8510	1.0069	1.0825	1.0240	1.0461	1.0336	1.0338
Nan yang	0.8969	1.0134	0.9059	1.0068	1.0117	1.0474	1.0247	1.0531	1.0456	1.0414
Ping ding shan	0.8968	1.0146	0.8005	1.0412	1.0017	0.9974	1.0472	1.0338	1.0492	1.0472
Pu yang	0.9120	1.0147	0.8659	1.0656	1.0061	1.0475	1.0369	1.0415	1.0342	1.0326
San men xia	0.9608	0.9194	0.8490	2.1606	1.0038	1.0468	0.9925	1.0501	1.0214	1.0308
Shang qiu	0.8973	1.0145	0.8003	1.1518	1.0046	1.0451	1.0239	1.0456	1.0640	1.0284
Xin xiang	0.9181	1.0083	0.8003	0.8085	1.0039	0.8970	1.0237	1.0450	1.1007	1.1186
Xin yang	0.9389	1.0145	0.8002	0.6797	1.0068	1.0478	1.0398	1.0371	1.0325	1.0311
Xu chang	0.9362	1.0133	0.8708	0.6425	1.0044	1.0865	1.0811	1.0279	1.0396	0.9982
Zheng zhou	0.9430	1.0087	0.8902	1.0563	1.0087	1.0182	0.8100	1.0252	1.0045	1.0150
Zhou kou	0.9075	1.0145	0.8003	0.9798	1.0060	1.0461	1.0239	1.0501	1.0446	1.0322
Zhu ma dian	0.9224	0.9638	0.8003	0.6977	1.0045	0.8815	1.0237	0.9939	1.0479	1.0434

In order to accurately find out the evolution of the green total factor productivity of the logistics industry in Henan Province, Henan Province is divided into five regions for comparison: Yudong (Kaifeng, Shangqiu and Zhoukou), Yuxi (Luoyang, Sanmenxia, Jiyuan and Jiaozuo). Yunan (Nanyang, Zhumadian and Xinyang), Yubei (Xinxiang, Hebi, Anyang and Puyang), Yuzhong (Xuchang, Pingdingshan, Luohe and Zhengzhou), and then to study the time of green total factor productivity of logistics industry in Henan Province spatial evolution characteristics.

3.2. Evolution of the Spatial and Temporal Pattern of Green Total Factor Productivity in Logistics Industry

3.2.1. Time series evolution characteristics of green total factor productivity in logistics industry

From the historical average of the green total factor productivity of the logistics industry, the province as a whole is in an efficiency-increasing state, both of which have risen to varying degrees, but the efficiency value is still less than one. Before 2009, the whole province was in a state of declining efficiency. This is related to the extensive development mode of the logistics industry. It relies on increasing the input of resource elements and increasing the scale of the industry to stimulate growth, without paying attention to the improvement of green efficiency. In addition, the decline began in 2008, which is related to the impact of the international financial crisis on the mainland logistics industry, affecting the normal development of the industry; after 2009, the turnaround began. The State Council issued the “Regulations for the Adjustment and Revitalization of the Logistics Industry” in 2009. Henan Province responded to the national call and began to vigorously develop logistics. After 2012, the environmental efficiency curve and the environmental constraint curve are also considered without considering environmental factors. The efficiency curve considering environmental factors starts to rise slowly after 2013. This shows that measures such as structural adjustment and configuration optimization are gradually taking effect, and the logistics industry ushered in the opportunity of green development.

3.2.2. Analysis of the spatial pattern of green total factor productivity in logistics industry

The radar map is drawn based on the geometric mean of the green total factor productivity of the logistics industry (Figure 1). It can be seen that the distribution of efficiency values in the province in recent years is very uneven, and the regions vary greatly between 2009 and 2011. Only Sanmenxia has achieved DEA effectiveness, and the remaining cities have room for improvement. At the same time, it can be seen that the cities with the lowest green efficiency are Zhumadian, Jiyuan, Luoyang and Xinyang, ranking the last four in the province, with efficiency values of 0.95. It can be seen from the radar chart that Pingdingshan ranks first for the first echelon, and Zhumadian falls to the lowest efficiency for the fourth gradient, and the difference between the two cities is the largest; For the second echelon, Xinxiang, Pingdingshan, Nanyang, Jiaozuo, Hebi, Anyang and Zhoukou are equally efficient; For the third echelon point Zhengzhou and Xuchang, the location is Superior and the efficiency is insufficient. The main reasons for these characteristics are: the logistics foundation of different regions is weak, and the regional differences are more obvious, and the investment and construction level in environmental protection, energy conservation and consumption reduction are relatively low. In addition, some developed regions fail to fully demonstrate their advantages in terms of production efficiency, which is related to the diminishing marginal benefits. At the same time, the benefits brought about by economic and environmentally friendly society construction have not yet fully manifested.

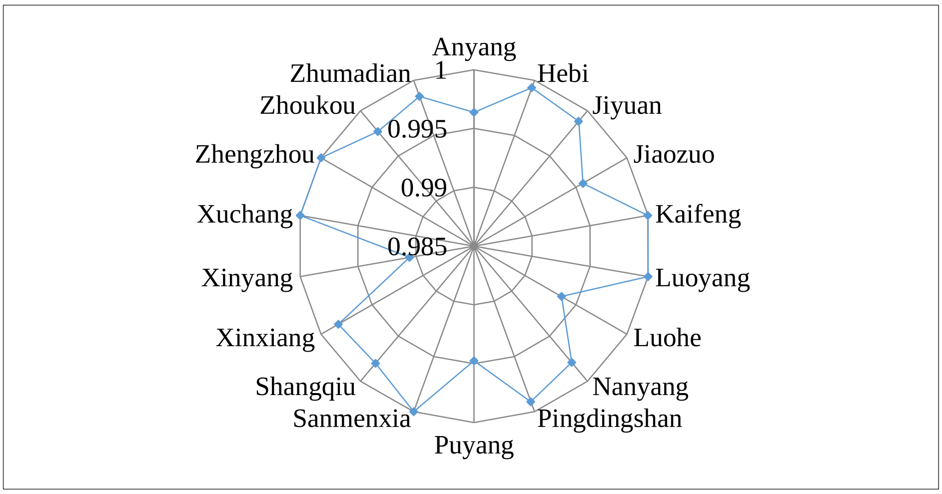

Figure 1. Evolution trend of total factor productivity of logistics industry in Henan Provinc

3.2.3. Evolution characteristics of regional total difference productivity of logistics industry

According to the measured efficiency value, combined with the standard deviation and coefficient of variation formula, the regional difference evolution trend is obtained (Figure2). Among them, the standard deviation of the efficiency value reflects the absolute difference of the region, and the coefficient of variation reflects the relative difference. It is not difficult to see that the absolute difference in the green total factor productivity of the logistics industry in Henan Province has shown a fluctuating trend. The highest value appeared in 2010 (0.3368), and the lowest value in 2011 (0.0021), the largest difference in one year. The relative differences in the region showed the same trend, from 0.344 in 2010 to 0. 0021, and the decline was most obvious in 2011, and then fluctuated up and down. Both differences showed a decline in 2010, mainly due to the impact of the financial crisis, logistics is more severely blocked. In addition, the relative differences show an overall increase trend, mainly due to the uneven development of the region, and some regions have increased investment in the logistics industry, taking the lead in technological upgrading, developing new logistics with low energy consumption and high efficiency, and focusing on Zhengzhou as the core region. The development of high-speed rail has slowed the development of logistics, resulting in differences in green total factor productivity in the region.

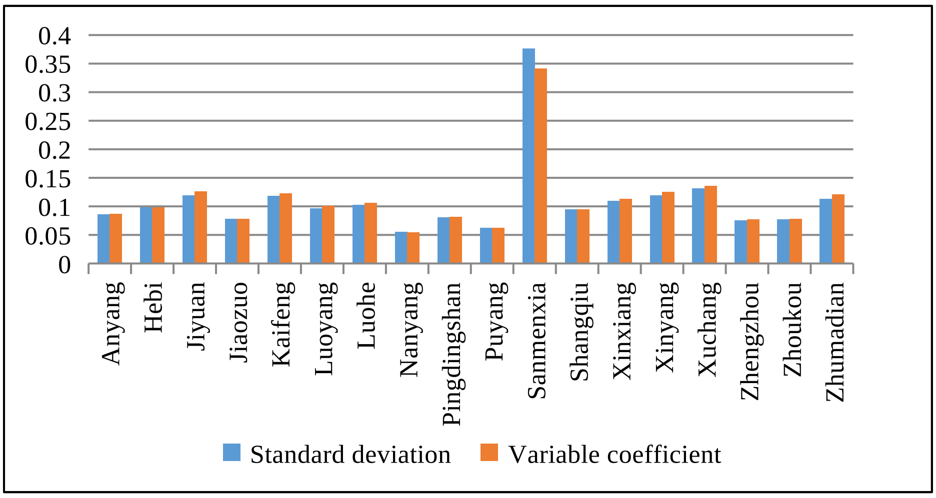

Figure 2. Standard deviation and coefficient of variation trend of green total factor productivity in logistics industry

3.3. Dynamic Evolution of Green Total Factor Productivity and Its Decomposition in Logistics Industry

3.3.1. Analysis of the Overall Characteristics of Green Total Factor Productivity and Its Decomposition in Logistics Industry

Combined with the ML index with undesired output and its decomposition formula, the green total factor productivity of the logistics industry and its decomposition index value can be calculated. From the average green total factor productivity change index, technical efficiency change index and technological progress change index chart of each province (Figure 3), it can be seen that both indexes show a volatility trend, and the ML index shows a decline in 2008-2009, and then presents Fluctuations up and down, rising again in 2013, which is related to the decline in international logistics demand from 2008 to 2009 and the initial implementation of the green development strategy in 2013; The technical progress index is basically consistent with the ML index; while the technical efficiency index is relatively stable and less affected by the external environment, but it has not been significantly improved. After 2012, the green total factor productivity of the logistics industry began to climb, mainly due to the advancement of logistics related technologies.

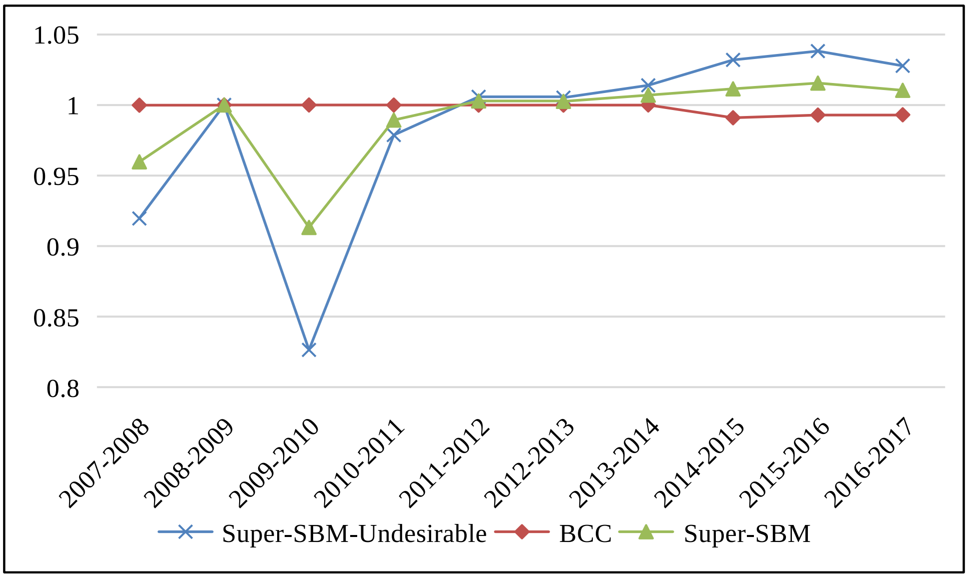

Figure 3. Logistics industry green total factor productivity machine decomposition index

3.3.2. Analysis of the time and space pattern of green total factor productivity and its decomposition in logistics industry

According to the changes in the green total factor productivity of the logistics industry and its decomposition results, the historical averages of the indicators in the five economic zones can be obtained (Figure 4). It can be seen from figure. 4 that for the ML index, only the average annual value of the Western Henan calendar is close to 1, reaching 0.996, and the change indices of the other regions are obvious; For the technical efficiency index, the two regions of Yuxi and Yudong are leading, reaching 0.9986 and 0.9985 respectively; This further proves that there are certain regional differences in the green total factor productivity of the logistics industry. The main reasons for these characteristics are: The logistics network in the west of Henan is developed, the logistics technology is relatively mature, and the R&D level and technology exchange are in a leading position. It is possible to try advanced technology first; The Yudong region is relatively better at using advanced management methods, and taking advantage of scale and macroeconomic policies to bring the growth of green total factor productivity of the animal industry. In addition, from the perspective of time series, we can see that the fluctuations of different indices in the five major economic zones show that the economic regions with large fluctuations are concentrated in the Yuzhong region, while the fluctuations in the

Yudong and Yuxi regions are relatively stable, mainly due to the relatively developed logistics network in the surrounding areas. The logistics industry in Henan Province is relatively backward, mainly because Henan Province has vigorously developed high-speed rail in recent years, and a large amount of capital is invested in railways. The investment in green logistics is relatively small, which makes the development of green total factor productivity in Henan logistics industry slow.

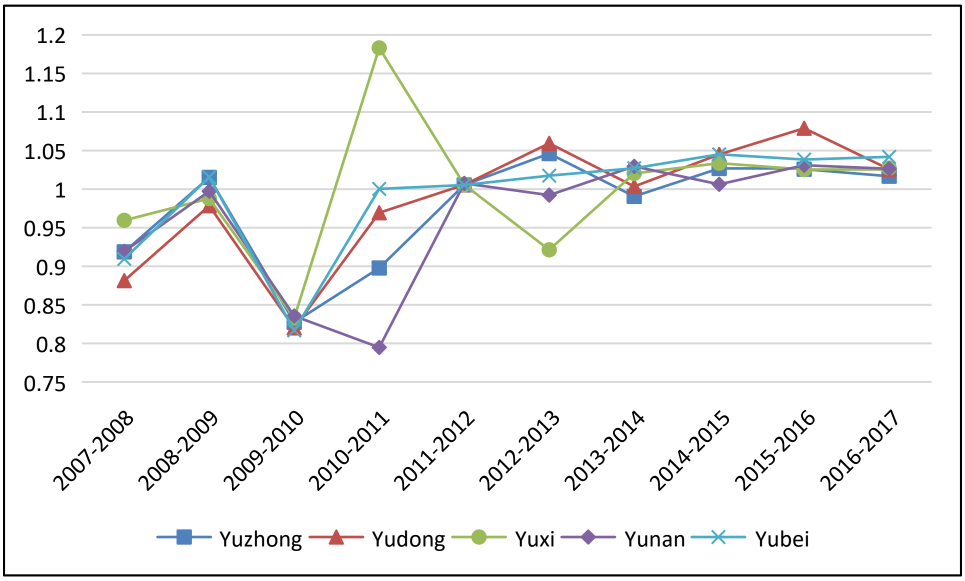

Figure 4. Green total factor productivity of logistics industry in different regions of Henan Province

4. Analysis on the Evolution Stage and Motivation of Green Total Factor Productivity in Logistics Industry

According to the time series characteristics of the global total factor productivity of the logistics industry, the evolution of the spatial pattern and the dynamic evolution of the decomposition index, the evolution of the green total factor productivity of the logistics industry since 2007 can be divided into three stages, and then combined with the internal and external development of the logistics industry. Factors and main driving forces at each stage to construct the evolution and motivation analysis framework of green total factor productivity in logistics industry.

(1) The stage of decline in green total factor productivity in the logistics industry (2007-2010). With the promulgation of the "Restructuring and Revitalization Plan for Logistics" issued by the State Council in 2009, the logistics industry in Henan Province began to turn around, and the efficiency of the logistics industry began to climb. At the same time, the national economy ushered in a period of rapid development, the demand for social logistics increased significantly, and the logistics industry was in a stage of rapid development. However, the main focus was on low-end logistics, and the market concentration was low, resulting in serious unreasonable conditions such as repeated transportation and long-distance air transportation. In addition, due to the large differences in economic development level and logistics infrastructure between regions, there are differences in the level of logistics between regions; at the same time, the level of logistics technology is low, the management level is backward, and the development of intensive, shared and cooperative development is excessive. Over-reliance on high-input and high-consumption development methods leads to low environmental benefits and green total factor productivity is still declining.

(2) The recovery phase of green total factor productivity in the logistics industry (2010-2011). In 2008, it experienced financial turmoil, and the international and domestic logistics demand declined. In 2009, the Standing Committee of the State Council reviewed and approved the logistics industry as the tenth industry in the ten major industrial revitalization plans, providing policy support for the adjustment and revitalization of the industry. Subsequently, the central and local governments continued to introduce relevant plans to guide the transformation of logistics development methods

and stimulate enterprise management and technological innovation. Due to the short-term effects of macro-control and regional planning, and the transfer of traditional logistics with high pollution and high energy consumption, the green efficiency of the receiving area is still low, the green total factor productivity has not been significantly improved, and the efficiency curve shows a steady-state feature.

(3) The recovery phase of green total factor productivity in the logistics industry (2012-2016). After 2012, the effects of national macro-control, environmental control investment, and policy investment gradually emerged, and the green total factor productivity of the logistics industry began to recover. As traditional logistics gradually fails to meet market demand, Henan Province has begun to focus on technology research and development, especially the application of information and network technology to drive the integration of traditional logistics industry into logistics, capital flow and information flow. In addition, the decisive role played by the market in resource allocation has forced companies to upgrade their technology, innovate management methods to increase market competitiveness, and to phase out inefficient companies.

5. Conclusions and recommendations

The Super-SBM model based on undesired output and the ML index are studied. The spatial and temporal evolution analysis of the green factor productivity and its decomposition of logistics industry in Henan Province from 2007 to 2017 is carried out, and the evolution stage and motivation of green total factor productivity are distinguished. Main conclusions and suggestions are as follows:

(1) The total factor production efficiency value of the logistics industry without considering the undesired output is higher than the green efficiency value considering the undesired output, indicating that the undesired output has a significant impact on the true efficiency, and the calculation result of the undesired output is more realistic. Henan Province's logistics industry needs to be upgraded. We should pay attention to the advantages of the composite industry of the logistics industry, do a good job in production and service, change the simple traditional logistics mode, further transform to modern logistics, provide high-tech, high value-added services, and improve the economic benefits of the entire industry; At the same time, we should pay attention to the application of clean energy and green technology, strengthen low-carbon awareness, and control energy consumption.

(2) The logistics industry in different regions is unevenly developed between regions, and the efficiency of surrounding areas is relatively high. However, the efficiency of logistics between provinces has also changed after adding non-expected factors; the regional absolute difference in green total factor productivity presents a fluctuating trend, while the relative difference also shows a fluctuating trend. To improve this situation, we should promote the coordinated development of regional economy and regional logistics, build a platform for sharing information and technology, and enable more developed technologies and advanced management methods in underdeveloped regions. At the same time, we should promote the rational allocation of logistics resources in more regions by means of personnel transportation, policy support and regional planning, break down local barriers and strengthen the interregional linkage development.

(3) The green total factor productivity, technological progress and technical efficiency of the logistics industry all show a fluctuating trend. In general, technological progress has a greater effect on green total factor productivity; there are differences in the fluctuations of the three indices between regions, and the developed regions are more affected by external disturbances, while the surrounding regions are relatively stable. This requires strengthening the innovation and research and development of logistics technology, stimulating the innovation of product customization to create a different lifestyle, shaping the consumption style that others can hardly copy, and pursuing distinctive product purchase and use behaviors.

(4) Enterprises should strengthen the level of consumer participation in product design in online personalized product customization. This is because the realization of self-construction and the expression of personal image require the consumer to integrate into the manufacturing stage of the product. In fact, the most direct means is to help consumers present their preferences and needs before

the various custom attributes of the product are determined. This ensures that the final personalized product can directly display consumption regardless of appearance properties or visual effects. The self-image and attributes of the person enhance the product involvement and help to improve the consumer's product customization intention.

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