Efficiency Evaluation Analysis of Listed Logistics Enterprises Based on Super-Efficiency SBM Model

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Abstract. As the pioneer of the logistics industry, the development of listed logistics companies is crucial to the whole industry. In order to solve the problem of measuring the efficiency of logistics companies with excess inputs and insufficient outputs, this study takes 43 listed logistics companies in China as the research object, and adopts the super-efficiency SBM model to measure their operational efficiency during 2013-2022, and jointly analyzes the changes in operational efficiency caused by the Global Malmquist-Luenberger Index. The dynamic analysis of the changes in the operational efficiency of enterprises is carried out in conjunction with the GML index Model. The conclusion shows that the input-output efficiency of most of the enterprises is still at a low level, based on which, development suggestions are provided for logistics enterprises in terms of technical efficiency and technological progress.

Keywords: listed logistics enterprises, enterprise efficiency, super-efficiency SBM model, GML index

1 INTRODUCTION

According to the National Logistics Operation Circular 2022 issued by the National Development and Reform Commission and the China Federation of Logistics and Purchasing, the total social logistics of the country in 2022 amounted to RMB 347.6 trillion yuan, with a year-on-year growth of 3.4% at comparable prices, and the scale of logistics demand has reached a new level; the total social logistics costs amounted to RMB 17.8 trillion yuan, with a year-on-year growth of 4.4%, and the ratio of the total social logistics costs The ratio of the total cost of social logistics to GDP was 14.7%, an increase of 0.1 percentage points over the previous year; the total revenue of the logistics industry was 12.7 trillion yuan, an increase of 4.7% year-on-year[1].Despite the fact that on the whole, the scale of logistics demand went to a new level and achieved stable growth. However, the ratio of China's total logistics costs to GDP is much higher than that of developed countries, and the high logistics costs reflect the urgent need to improve the efficiency of China's logistics enterprises[2].

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The development of listed logistics companies, as the vanguard of the logistics industry, is crucial to the whole logistics industry. The development of listed logistics companies, as the vanguard of the logistics industry, is crucial to the whole logistics industry. Existing research has achieved rich results, scholars mostly from the perspective of input and output, using DEA and its expansion model to measure the operational efficiency of enterprises. Zhang Peiwen used the three-stage DEA model, eliminated the influence of random and environmental factors on the empirical results, and measured the operational efficiency of air transportation enterprises [3]. Chen Gang used DEA model to study the operational efficiency of listed retail enterprises measured the total factor productivity of retail enterprises by Malmquist index [4]. Kong Weiwei et al. measured the efficiency of China's logistics enterprises with the help of the DEA model, and used the Tobit model to verify the internal and external factors affecting the efficiency, and accordingly put forward strategies for improvement [5]. Traditional DEA analysis often results in multiple decision units that are effective but indistinguishable from each other in terms of efficiency, but super-efficiency allows these decision units to be differentiated and ranked. In order to solve the problem of efficiency measurement when there is an excess of inputs and a shortage of outputs, this study takes 43 listed logistics enterprises in China as the research object, adopts the super-efficiency SBM model to measure the operational efficiency of 43 listed logistics enterprises during the period of 2013-2022, and combines with the GML index provides a dynamic analysis of the changes that cause changes in the operational efficiency of firms.

2 RESEARCH METHODOLOGY

2.1 Super-Efficiency SBM Model

The super-efficient SBM model that considers undesired outputs used in this paper is one of the DEA models that breaks away from the previous problem of considering only positive outputs and not negative outputs[6]. This index compensates for the shortcomings of the traditional ML index, has the transferability and can be cumulatively multiplied, and can calculate the changes in productivity of decision-making units in different periods [7].

In this paper, the operational efficiency level of logistics enterprises is evaluated by using the super-efficient SBM model that considers the desired output, and its specific model expression is as follows:

$$\min\rho=\frac{1-\frac{1}{m}\sum_{i=1}^{m}\left(\frac{r_i^-}{x_{ik}}\right)}{1+\frac{1}{s_1+s_2}\left(\sum_{w=1}^{s_1}\frac{r_w^d}{y_{wk}^d}+\sum_{g=1}^{r_2}\frac{r_g^u}{y_{gk}^u}\right)} \tag{1}$$

$$s.t.\begin{cases} x_{ik} \geq \sum_{j=1, j\neq k}^{n} x_{ij} Q_j - r_i^- \\ y_{wk}^d \leq \sum_{j=1, j\neq k}^{n} y_{wj} Q_j + r_w^d \\ y_{gk}^u \geq \sum_{j=1, j\neq k}^{n} y_{gj} Q_j - r_g^u \\ \sum_{j=1, j\neq k}^{n} Q_j = 1 \\ Q_j, r_i^-, r_w^d, r_g^u \geq 0 \\ i = 1,2,...,m; w = 1,2,...,S_1; g = 1,2,...,S_2; j = 1,2,...,n \end{cases} \tag{2}$$

2.2 Global Malmquist-Luenberger Index Model

Oh et al. constructed the Global Malmquist-Luenberger index model, or GML index, by incorporating global production techniques into the ML index[8]. This index makes up for the shortcomings of the traditional ML index, and has the transferability to be able to carry out cumulative multiplication, which can then compare the efficiency of regional enterprises in different periods,and responds to the change rule of efficiency from period t to period t+1. Based on this, the this paper chooses the GML index to explore the changes in the operational efficiency of listed logistics enterprises, and the basic expressions of its decomposition model are as follows：

$$GML(t-1,t) = \frac{E_g(x_t, y_t)}{E_g(x_{t-1}, y_{t-1})} \tag{3}$$

$$EC(t-1,t) = \frac{E_t(x_t, y_t)}{E_t(x_{t-1}, y_{t-1})} \tag{4}$$

$$TC(t-1,t) = \frac{GML(t-1,t)}{EC(t-1,t)} = \frac{\dfrac{E_g(x_t, y_t)}{E_g(x_{t-1}, y_{t-1})}}{\dfrac{E_t(x_t, y_t)}{E_t(x_{t-1}, y_{t-1})}} \tag{5}$$

3 INDICATORS AND DATA SOURCES

According to the current situation of domestic listed logistics companies and the principles of indicator construction, the existing literature on input and output efficiency of enterprises is sorted out and summarized[9][10][11]. It is found that most scholars select the corresponding input indicators from human, financial and material aspects, and the output indicators mainly focus on net profit, EVA, earnings per share, operating income and so on. Therefore,considering data availability and validity, this paper selects operating costs, administrative expenses, employee compensation payable and net fixed assets as input indicators to reflect the operating costs, labor costs and asset

scale of the enterprise; and selects operating income and net profit as output indicators to reflect the enterprise's profitability, operating capacity and profitability.

Since the latest "Guidelines on Industry Classification of Listed Companies" does not specify the logistics industry, this paper draws on the experience of previous studies and chooses to replace the logistics industry with the transportation, warehousing and postal industry. A total of 118 A-share, non-ST stock, transportation, warehousing and postal companies as defined in the 2012 version of the industry classification of the Securities and Futures Commission (SFC) are selected from the CSMAR database for the period of 2013-2022, excluding ST, SST, *ST and other listed companies, companies with missing financial data, and companies with negative input/output indicators, 43 listed logistics companies were finally selected as research samples.

4 DATA ANALYSIS

4.1 Analysis of the Results of SBM Model

This part adopts Super-SBM model and uses Matlab software to measure the average efficiency value of 43 logistics listed companies in China from 2013 to 2022, and analyzes the measurement results. Table 1 shows the mean value of super efficiency and ranking of each sample company:

Table 1. Average and Ranking of Listed Logistics Companies in terms of Super-Efficiency, 2013-2022

Enterprises Stock Code	average	Ranking	Enterprises Stock Code	average	Ranking	Enterprises Stock Code	average	Ranking
600106	1.016	1	601018	0.459	16	600650	0.147	31
600377	0.925	2	600035	0.427	17	600017	0.136	32
601006	0.907	3	600020	0.421	18	002040	0.125	33
600834	0.839	4	600787	0.408	19	000099	0.106	34
600018	0.794	5	601518	0.390	20	002357	0.106	35
600033	0.777	6	000548	0.370	21	000905	0.103	36
601107	0.769	7	002492	0.322	22	601880	0.100	37
000828	0.754	8	600897	0.251	23	002627	0.089	38
601188	0.740	9	601000	0.212	24	600279	0.082	39
600350	0.712	10	000900	0.198	25	000507	0.072	40
600012	0.692	11	603167	0.195	26	600190	0.060	41
600125	0.622	12	600269	0.172	27	601008	0.057	42
603128	0.577	13	002320	0.165	28	600428	0.027	43
000429	0.568	14	600717	0.160	29	-	-	-
000088	0.502	15	000582	0.155	30	-	-	-

From the ranking of the mean value results, Chongqing Road and Bridge's super-efficiency mean value under the Super-SBM model ranks first, indicating that Chong-

qing Road and Bridge's(600106)resource allocation is more reasonable during the sample period, and its input and output efficiency are located in the production frontier, in the effective state where there is no redundancy of inputs and no shortage of outputs. The lowest enterprise for the COSCO SHIPPING Specialized Carriers Co., Ltd(600428), only 0.027, a larger space to rise, the difference between the two is huge, indicating that the development of the listed logistics companies there are large gaps, which is consistent with the development of the quality of the various logistics enterprises, reflecting the reasonableness of this study. From the specific super-efficiency value of each sample enterprise in each year, the average super-efficiency value of 43 listed logistics enterprises is 0.389, and there are 20 enterprises located above the average comprehensive efficiency value, Indicates that the input-output efficiency of these firms over the 10-year period is ideal, and the operational efficiency and management level are higher compared with other logistics enterprises.

4.2 Analysis of the Results of GML Index Model

This part also uses MATLAB software to measure the GML index of operational efficiency of 43 enterprises in China from 2013 to 2022, and decomposes it into the technical progress index TC and the technical efficiency change index EC.This part will be analyzed from both the national perspective and the regional perspective, so as to compare and analyze the causes of the changes in the efficiency of the logistics enterprises in different regions in a more objective way.

GML Index of Efficiency of Listed Logistics Firms in National Perspective. As shown in Table 2, the mean values of GML index, technical progress index (TC) and technical efficiency change index (EC) of the efficiency of China's logistics enterprises in 2013-2022 are 1.091, 1.036 and 1.167 respectively, which are all greater than 1, which implies that the development of China's logistics enterprises in general is positive.

Table 2. Efficiency GML Index and its Decomposition for Listed Logistics Companies, 2013-2022

Age	GML	TC	EC
2013-2014	1.172	0.952	1.273
2014-2015	0.985	0.942	1.124
2015-2016	0.918	1.094	0.885
2016-2017	1.413	1.275	1.189
2017-2018	0.987	1.208	0.924
2018-2019	1.051	0.974	1.133
2019-2020	0.917	0.764	1.271
2020-2021	1.471	1.371	1.112
2021-2022	0.904	0.749	1.596
Average	1.091	1.036	1.167

From the GML index, the five periods of 2014-2015, 2015-2016, 2017-2018, 2019-2020 and 2021-2022 have a GML index of less than 1, which indicates that the overall efficiency of China's listed logistics enterprises has declined in the above five periods, and the decline during the period of 2021-2022 is the largest. The other time periods GML index is greater than 1, that is, the efficiency level of enterprises in these time periods are on an upward trend.

In 2016-2017 and 2020-2021, under the role of technological progress and technical efficiency jointly promoted, the growth rate of enterprise operational efficiency level is accelerating, and the growth rate of technological progress is faster and the role of promotion is also greater, which indicates that the catching-up effect in these two time periods is obvious, and its technical efficiency is constantly approaching the production frontier.

GML Index of Efficiency of Listed Logistics Firms in Regional Perspective. In order to objectively assess the development status of the logistics industry in different regions and compare the efficiency differences between them, and to promote the balanced cross-regional flow of resource factors and provide policy recommendations, the sample enterprises were divided into five segments, namely, East China, North China, Central and South China, Southwest China, and Northeast China, based on the registered addresses of the listed logistics enterprises.

Table 3 reports the GML index and its decomposition results for each administrative region of the country for the period 2013-2022. As can be seen from the table, the GML indexes of all regions are greater than 1, indicating that the enterprise efficiency of each region grows under the joint growth of TC and EC. From the decomposition of the GML index, the TC index of the Southwest region is less than 1, which indicates that the technical progress index of the Southwest region has regressed and the growth of enterprise efficiency has benefited from the improvement of technical efficiency. The EC of East China, Central and South China, Southwest China, and Northeast China are all greater than 1 and exceed the TC, with an obvious catch-up effect, indicating that the improvement of enterprise efficiency in these regions is more due to the improvement of technical efficiency such as management level and resource allocation efficiency, while the improvement of enterprise efficiency in North China still needs to rely on the improvement of technology, drawing on the technological improvement, reorganization, and management styles of the above regions.

Table 3. Efficiency GML index and its decomposition for listed logistics companies in each administrative region

	GML	TC	EC
East China	1.054	1.019	1.092
North China	1.088	1.100	1.043
Central and South China	1.134	1.054	1.198
Southwest China	1.058	0.984	1.559
Northeast China	1.109	1.018	1.118

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions.

From the data results, the Super-SBM model mainly reveals the overall characteristics of the operational efficiency of listed logistics enterprises in China. The results show that during the study period, the overall operational efficiency of logistics enterprises in China is not high, and there is a big gap between the development of each listed logistics enterprise, and most of them have not reached the effective state of input and output efficiency. It indicates that the overall operational efficiency of listed logistics enterprises in China is poor and lacks a scientific, standardized and regulated business model; while the GML index and its decomposition mainly reflect the dynamic changes in the operational efficiency of enterprises. The analysis shows that technological progress and technical efficiency in the national perspective have a positive effect on the improvement of the efficiency of logistics enterprises, but the bottleneck of development is mainly in technological progress; in the regional perspective, although the GML index is the highest in the central and southern regions, the GML index of each region is greater than 1, which indicates that China's logistics enterprises are generally upwardly mobile. Among them, the technological progress index in the southwest region has undergone a regression, which needs to be improved from the aspect of technological progress in terms of enterprise operation mode and innovation development.

From the perspective of management revelation, in order to realize long-term development, logistics enterprises must follow the national policy, grasp the overall situation, and formulate enterprise development plans according to the national policy. The study is conducive to understanding the operational status of China's logistics enterprises, studying the optimal resource allocation enterprises, and analyzing their high efficiency experience, improving the overall input-output efficiency of the industry, and accelerating the modernization process of China's logistics industry has certain theoretical significance and practical significance. Exceptionally, it can also provide certain observable theoretical basis for the state and the government to formulate corresponding policies and measures, and put forward corresponding opinions and suggestions according to the regional development differences, to ensure that it is in line with the actual situation of regional development. Thus promoting the efficient and high-quality development of the logistics industry and narrowing the gap with developed countries.

5.2 Recommendations

Firstly, enterprises can improve their technical inefficiency by optimizing the allocation of human resources, standardizing the enterprise management system, strengthening departmental synergies and cooperation, joining forces with external intensive development, formulating diversified development strategies, transforming competitive relationships into collaborative relationships, and improving dynamic resilience and market competitiveness.

Secondly, technological progress of enterprises is equally important. Enterprises need to learn advanced operation and management methods, open up innovative thinking, realize information sharing and resource integration through information platforms, and strengthen the innovation of logistics information technology, so as to continuously optimize and upgrade, and achieve high efficiency of input and output.

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