Efficiency Evaluation System of Guangzhou Fresh Agricultural Products Cold Chain Logistics Industry under Low Carbon Economy

Lianying Xiao[1,2,a], Pengliang Qiao[2,b], Wenhao Li[2,c], Xiaoxia Fan[2,d], HongYu Liu[2,e], Shaharudin Muhammad Shabira[1*]

[1]School of Management, University Sains Malaysia, Penang, 11900 Malaysia
[2]School of Management, Guangzhou College of Technology and Business, GuangZhou, 510000 China

[a]xiaolianying@student.usm.my, [b]qpliang@gzgs.edu.cn, [c]lwh@gzgs.edu.cn, [d]fxx@gzgs.edu.cn , [e] liuhongyu@gzgs.edu.cn
*Corresponding author's e-mail: Shabir@usm.my

Abstract. Based on the standardization process of logistics efficiency evaluation and combined with the development concept of low-carbon logistics, this paper constructs a scientific and reasonable logistics efficiency evaluation index system and model, aiming at comprehensively and accurately reflecting the efficiency level of Guangzhou fresh agricultural products cold chain logistics industry.

Keywords: Low carbon economy; fresh produce; cold chain logistics

1 Introduction

This paper draws on the research methods of Zhang Jiawei [1] and Yu Meng [2], and combines the DEA evaluation model to construct the index system for measuring the efficiency of fresh agricultural products cold chain logistics under the low-carbon perspective. The DEA model was chosen to analyze the cold chain logistics efficiency of fresh agricultural products in Guangzhou City in depth, and the deap2.1 software was used to analyze the dynamic efficiency change of fresh agricultural products logistics in Guangzhou City under the low-carbon economy from 2014 to 2022.

Brain Tomlin (2003) assessed the various types of influencing factors in the cold chain logistics system of fresh agricultural products to obtain the weights of each factor. The matrix was then constructed using the grid search method to effectively draw a matrix diagram of the cold chain logistics system, thus more intuitively showing the structure and characteristics of the cold chain logistics system for fresh agricultural products [3]. While Mejjaouli (2018) focused on the study of transportation and storage conditions of fresh agricultural products [4].

Leng Kaijun (2017) chose Hubei Province as the object of study, and first explored the problems faced by the cold chain logistics of fresh agricultural products in Hubei

C. W. K. Chen et al. (eds.), *Proceedings of the 9th International Conference on Engineering Management and the 2nd Forum on Modern Logistics and Supply Chain Management (ICEM-MLSCM 2024)*,
Advances in Engineering Research 243,
https://doi.org/10.2991/978-94-6463-531-7_9

Province in the period of the new stage of economic development [5]. Sun Yuting (2022) conducted a comprehensive research on the current situation of cold chain logistics development in China, and carried out an in-depth analysis from multiple dimensions such as cold chain logistics market, network layout and government policies [6].

In the study of logistics efficiency, scholars mostly use the data envelopment analysis (Data envelopment analysis,DEA) method to construct different evaluation index system to carry out the measurement and evaluation of logistics efficiency.RitaMarkovits-Somogyi(2014) used the model combining DEA and PC with Europe as the research object, according to logistics efficiency indicators of "logistics quality and capacity" to assess efficiency [7] .Kamran Rashidi (2019) used data envelopment analysis (DEA) to assess the sustainability of logistics performance in each country [8]. National scholar Ni Zhimin (2017) applied the CCR model of the data envelopment analysis (DEA) method in depth in his study [9]. And Yu Liying (2018) utilized the DEA-Malmquist model to conduct an in-depth study on the logistics efficiency of 11 provinces and cities in the Yangtze River Economic Belt between 2008 and 2015. She analyzed the logistics efficiency status of each province in detail and came up with new research results. This study provides important theoretical support and practical guidance for the optimization and development of the logistics industry in the Yangtze River Economic Belt [10].

2 Efficiency Indicators and Data Sources

The data were mainly obtained from the official website of the Bureau of Statistics, Guangdong Statistical Yearbook and China Energy Statistical Yearbook.

Data packet network analysis (DEA) is a method to analyze the efficiency of decision-making units based on multiple input and output indicators using linear programming. Table 1 demonstrates specific cold chain logistics industry efficiency evaluation indicators

Table 1. Eficiency Evaluation Indicators for the Cold Chain Logistics Industry

	Level 1 indicators	Level 2 indicators	Level 3 indicators
Low-carbon fresh agricultural products cold chain logistics efficiency evaluation index system	Fresh agricultural Products cold chain logistics industry input index	Infrastructure	Logistics mileage (km)
		labor	Number of people working in Logistics industry (people)
		Capital	Fixed asset investment of logistics (ten thousand yuan)
		Environmental constraint	Logistics CO2discharge
	Output index	Quality output	Increase in the amount
		Quantity output	Freight volume

2.1 Transverse Data

In Guangzhou city fresh agricultural products logistics industry CO2Emission data statistics, using the respective CO2Eemission coefficient, the energy consumption of raw coal, gasoline, diesel and 2natural gas is calculated one by one, so as to get the corresponding CO2discharge.

According to the principle of operability, namely to the total number of Guangzhou transportation workers (N) multiplied by the final consumption rate (r1) multiplied by the final consumption (r2), estimate the residents and the final consumption matching, finally multiplied by the engel coefficient (e), to estimate the number of fresh agricultural products logistics (X), namely: $X = N \times r1 \times r2 \times e$.

Fresh agricultural products logistics fixed assets investment. In the same way as the fresh agricultural products logistics practitioners, the total fixed assets of the transportation industry are multiplied by the final consumption matching index of residents R to estimate the fixed assets investment of fresh agricultural products logistics in Guangzhou. Table 2 demonstrates the number of inputs and outputs in Guangzhou in 2018-2022, and this table specifically presents the corresponding calculation process and calculation method, applying the formula in a clear way.

Table 2. Input-output quantity in Guangzhou in 2018-2022

	Input	Input	Input	Input	Output	Output
years	Transport route mileage (km)	Number of people working in fresh agricultural products logistics industry (people)	Fixed asset investment of fresh agricultural products logistics (ten thousand yuan)	Fresh agricultural products logistics CO2Emissions (tons)	Turnover of fresh agricultural products and goods (ten thousand tons)	Total value of fresh agricultural products logistics industry (ten thousand yuan)
2013	16378	64627	2670634	4648513	39005	2342967
2014	16593	60039	2874666	4431880	46774	2613705
2015	16694	60917	2757726	4642243	48399	2766462
2016	17159	61048	3093288	4655925	74178	3043637
2017	17144	63298	3539796	4938880	96313	3689402
2018	16797	70117	3923504	5368918	84580	4545742
2019	16804	74016	4632126	5531773	118002	5407146
2020	16801	79741	4216251	4808709	131053	5785047
2021	16806	90494	4568902	4666946	125419	6353441
2022	16830	90155	4787578	3886873	139471	6934717

For CO2 emissions from fresh produce logistics, multiply the number of vehicles used in logistics in Guangzhou with the final consumption rate of residents to get the total number of vehicles used in fresh produce logistics in Guangzhou, and then multiply it with the energy consumption to get the CO2 emissions from fresh produce logistics.

Cargo turnover of fresh agricultural products is the product of the volume of each fresh agricultural product transported by a means of transportation and the distance it is transported. The formula is: fresh agricultural products cargo turnover= the total amount of fresh agricultural products × cargo transportation distance; cargo transportation distance=the total amount of regional freight turnover / regional freight volume. Fresh agricultural products logistics value. The formula is: fresh agricultural products logistics value=total output value of the logistics industry × final consumption matching index R.

3 Sample Data Processing Results

Using the DEAP 2.1 software, first, create a new txt file in the root directory of DEAP 2.1 for configuring the algorithm and parameters, and save the sample data in plain text format. Then, open the command line terminal of DEAP 2.1, specify the input file and start to calculate the cold chain logistics efficiency. After the program runs, DEAP 2.1 will generate a new txt file in the root directory for deriving the technical efficiency of the logistics industry. Table 3 shows the specific data of the efficiency table of Guangzhou fresh produce cold chain logistics industry under low carbon economy from 2013 to 2022.

Table 3 Efficiency table of Cold-chain Logistics Industry of Fresh Agricultural Products in Guangzhou under low-carbon economy in 2013-2022

Particular year	Technical efficiency	Pure technical efficiency	Scale efficiency	Return of scale
2013	0.606	1.000	0.606	irs
2014	0.628	1.000	0.628	irs
2015	0.693	1.000	0.693	irs
2016	0.771	1.000	0.771	irs
2017	0.926	1.000	0.926	irs
2018	0.843	1.000	0.843	irs
2019	0.988	1.000	0.988	irs
2020	1.000	1.000	1.000	-
2021	0.960	0.998	0.962	irs
2022	1.000	1.000	1.000	-
Average value	0.8415	0.9998	0.8417	

The specific data are 4 input variables and 2 output variables of 10 decision-making units, and the time span is from 2013 to 2022. In the measurement results, if the value of technical efficiency in a certain year is less than 1, it indicates that the technology of the logistics industry has not yet reached the optimal state in that year. On the contrary, if the technical efficiency value of a year is equal to 1, it indicates that the logistics industry technology in that year is leading in production and has reached the desired level of technical efficiency. The current level of logistics technology and management, as well as the scale of the logistics industry, can meet the needs of development.

4 Conclusions

In the analyzed data of technical efficiency of logistics industry, the average value of technical efficiency shows 0.8415, while the average value of pure technical efficiency is 0.998, and the average value of scale efficiency is 0.8417. It is worth noting that in both years 2020 and 2022, the comprehensive technical efficiency reaches 1, which shows that in these two years, the technical efficiency of fresh produce cold chain logistics industry reaches the DEA effective state.The above data fully illustrate the coordination between technology and overall development of fresh agricultural products cold chain logistics industry.The average value of comprehensive technical efficiency is 0.725 in 2013-2017, and the average value of comprehensive technical efficiency is 0.958 in 2018-2022.Through the analysis of the above data, the efficiency of fresh agricultural products cold chain logistics of Guangzhou City has been improving in recent years, and the overall is in a higher position, and the overall scale continues to rise in the early stage, and the overall scale is in a higher position. The overall scale continues to rise in the early stage and stabilizes in the later stage. However, in general, the average value of the overall comprehensive efficiency of fresh agricultural products cold chain logistics in Guangzhou is lower than 1. The results of the study show that the fresh agricultural products cold chain logistics industry in Guangzhou has not achieved the best output in the case of limiting the cost, labor input and carbon dioxide emission.The pure technical efficiency of Guangzhou fresh agricultural products logistics industry from 2013 to 2022 is 1 except for 2021, and the DEA is effective, which indicates that the development of Guangzhou fresh agricultural products logistics technology level is satisfied in this period. 2021 is the opening year of the Fourteenth Five-Year Plan, and there are multiple factors, such as the spreading of domestic epidemics, that cause the pure technical efficiency to fluctuate. Factors such as the opening year of the “14th Five-Year Plan”, the proliferation of domestic epidemics and other factors lead to the fluctuation of pure technical efficiency. As a result, the value of pure technical efficiency is very stable, which is not the key to affect the technical efficiency of fresh produce cold chain logistics in Guangzhou. During this period, although the technological level of fresh agricultural products logistics in Guangzhou is effective, in the long run, the fresh agricultural products logistics industry in Guangzhou still needs to continuously develop technology and resources to continuously improve efficiency.From the data, the DEA evaluation of the scale efficiency value of fresh produce cold chain logistics in Guangzhou City is valid for years such as 2020 and 2022, and the rest of the years do not reach 1, so the DEA is invalid. After in-depth analysis, it is observed that except for 2020 and 2022, the scale efficiency values of other years fail to exceed the pure technical efficiency values, and the difference in the early period is relatively large. This phenomenon is the key factor leading to the low comprehensive technical efficiency of Guangzhou. Specifically, the low scale efficiency mainly reflects that the rationality of the resource allocation of fresh agricultural products cold chain logistics in Guangzhou needs to be improved, as well as the adequacy of resource utilization needs to be strengthened.

Acknowledgements

This study was supported by the following projects, respectively:Project of China Society of Logistics (2023CSLKT3-166), (Project No. 2024CSLKT3-420); Guangdong Province Philosophy and Social Science Planning Youth Project (GD23YGL28), (GD24CGL26); Introduction to Cold Chain Logistics", (Project No. 202309); "Research on Strategies for High-Quality Development of Modern Logistics Industry", (Project No. 2024CSLKT1-001); (Project No. 2021ZDJS122) (Project No. 231006021102523); (Project No. 231105635271715)

References

1. Zhang J. (2023) Research on the efficiency evaluation and spatial evolution of fresh agricultural products logistics in Zhejiang Province. Zhejiang Ocean University.
2. Yu Meng. Research on efficiency evaluation of logistics industry in Hebei province based on the perspective of low carbon development [D]. Hebei University,2019.
3. TolinB.CapacityInvestmentsinSupplyChains:Sharingthegainratherthansharingthepain[J].Manufacturing&ServiceOperationsManagement,2003,5(4):317-333.
4. MejaoliS,BabiceanuRF.Coldsupplychainlogistics:Systemoptimizationforreal-timererouting transportationsolutions[J].ComputersinIndustry,2018,95:68-80.
5. Leng Kaijun, Jing Linbo, Pan Lin. Research on the status quo and problems of cold chain logistics development in Hubei Province under the new normal[J]. Theory Monthly, 2015(05):125-131.
6. Sun Yuting. Exploration and analysis of the development problems of cold chain logistics in China[J]. Theory observation,2022(02):74-78.
7. Ritkovits-Somogyi,ZoltanBokor.AssessingthelogisticsefficiencyofEuropeancountriesbyusingtheDEA-PCmethodology[J].Transport,2014,29(2):137-145.
8. KamranRshidi.EvaluatingthesustainabilityofnationallogisticsperformanceusingDataEnvelopmentAnalysis[J].TransportPolicy,2019(9):35-46.
9. Ni Zhimin. An empirical study on logistics efficiency and its influencing factors in Henan Province[J]. Journal of Henan University of Technology(Social Science Edition),2017,18(02):20-24.
10. YU Liying,SHI Mingkang,JING Li. Logistics efficiency and factor decomposition of the Yangtze River economic belt based on DEA-Malmquist index model[J]. Business Economics and Management,2018(04):16-25.