The Impact of Transportation Infrastructure on the Logistics Efficiency of Urban Agglomerations--Based on the Yangtze River Delta Urban Agglomeration

Congxi Wen[1,a] , Peng GAO[2,b], Yang GE[1,c], Lei LIU[2,d,*]

[1]Minjiang University, College of Management and Economics, Fuzhou, Fujian 350108, China

[2]Minjiang University, College of Mathematics and Data Science (Software College), Fuzhou, Fujian 350108, China

[a]ganyanjun7504@icloud.com,[b]1904696058@qq.com,[c]1119779915@qq.com.[d]3197102140@stu.mju.edu.cn

*Corresponding Author

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Abstract: Since the 21st century, with the proposal and implementation of the national urban agglomeration strategy and the country's massive investment in transportation infrastructure, my country's urban agglomerations have developed rapidly. The formation of an urban agglomeration is inseparable from the development of logistics, and the logistics efficiency of the urban agglomeration also determines the upper and lower limits of the development of an urban agglomeration. The efficiency of logistics depends on many factors, and this article will start from the aspect of transportation infrastructure. Based on the DEA model, four indicators are selected for analysis: the employees in the logistics industry in some cities in the Yangtze River Delta from 2019 to 2016, the actual road kilometers at the end of the year, the number of civilian trucks at the end of the year, and the freight volume of the logistics industry. The analysis results show that the reduction of transportation infrastructure will lead to the reduction of scale efficiency and pure technical efficiency, and then reduce the overall efficiency, which will lead to the decrease of logistics efficiency, but the increase of transportation infrastructure will not necessarily increase the overall efficiency and thus improve the logistics efficiency. Based on the analysis results, the following suggestions are drawn: (1) Local governments should increase and decrease relevant investments and policies flexibly according to local conditions. (2) The government should establish long-term and good cooperative relations with enterprises to jointly improve logistics efficiency. (3) Cities should cooperate with each other to improve the road network.

1. Introduction

As the engine of today's economic development, urban agglomerations have always attracted much attention. Whether it is the Pearl River Delta, the Yangtze River Delta or the Beijing-Tianjin-Hebei region, they always attract the attention of the whole country. As the process of urbanization continues to deepen, the construction of urban agglomerations continues to accelerate, and people's understanding of the interactive development of logistics and urban agglomerations has gradually deepened, and many scholars have also turned their attention to this. Such as the analysis of the logistics efficiency of the Yangtze River Delta port based on the DEA, the analysis of the transportation efficiency based on the DEA, the analysis of the logistics efficiency of the three major urban agglomerations in the eastern coastal area based on the DEA, and so on. However, there is a lack of analysis of the logistics efficiency of urban agglomerations from a single point of view of the transportation infrastructure to help clarify the importance of transportation infrastructure investment. The Yangtze River Delta is one of the most powerful engines in the urban agglomeration. Choosing the Yangtze River Delta as the object of discussion can better help us understand the impact of transportation infrastructure on logistics efficiency.

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2. Indicator Selection and Model Construction

2.1 Indicator Selection

This paper adopts the principles of systematicness, scientificity, objectivity, applicability and availability for the selection of indicators, and considers input and output at the same time. Based on the above principles and factors, this paper selects the indicators as follows: (1) Number of employees in logistics: The number of employees here is the sum of the three items of transportation, warehousing and postal services, which can reflect the input of human resources. (2) Existing road kilometers at the end of the year: As an indispensable part of the transportation infrastructure, the length of the road has a very high impact on the efficiency of the logistics industry, so it is included as an input indicator. (3) The actual number of civilian trucks at the end of the year: This indicator and roads are both crucial factors affecting the logistics efficiency. The number of vehicles determines the upper and lower limits of transporting goods. Include it as an input indicator as well. (4) Freight volume in the logistics industry: The level of freight volume reflects the development status of a city's logistics industry and the efficiency of urban logistics. At the same time, the volume of freight is also affected by three indicators: the number of employees, the number of road kilometers, and the number of trucks. So take it as an output indicator.

2.2 Construction of the Model

The research object of this paper is logistics efficiency. Compared with the output volume, the input volume is easier to control. For this reason, this paper chooses the input-oriented BCC model for analysis.

The model is as follows: Suppose there are n:

$$\begin{aligned} &x_j = \left(x_{1,}, x_{2j}, \cdots x_{mj}\right)^T \succ 0,\ j = 1, 2 \cdots, n \\ &y_j = \left(y_{1,j}, y_{2j} \cdots, y_{mj}\right)^T > 0,\ j = 1, 2 \cdots, n \\ &\omega = \left(\omega_1 \omega_2, \cdots, \omega_m\right)^T > 0 \\ &\mu = \left(\mu_1, \mu_2, \cdots, \mu_s\right)^T > 0 \end{aligned} \tag{1}$$

Then the BCC model can be expressed as:

$$\max\left(\mu^T y_0 + \mu_0\right) \quad s.t. \begin{cases} \mu^T x_j - \mu^T y_j - \mu_0 \geq 0,\ j = 1, 2, \cdots, n \\ \omega^T x_0 = 1 \\ \omega \geq \varepsilon \hat{e} \\ \mu \geq \varepsilon e \end{cases} \tag{2}$$

The dual form of the BCC model can be expressed as:

$$\min \theta - \varepsilon\left(\hat{e}^T s^- + e^T s^+\right) \quad s.t. \begin{cases} \sum_{i=1}^{n} x_i \lambda_i + s^- = \theta x_0 \\ \sum_{i=1}^{n} y_i \lambda_i - s^+ = y_0 \\ \sum_{j=1}^{n} y_j \lambda_j = 1 \\ \lambda_i \geq 0, s^-, s^+ \geq 0 \end{cases} \tag{3}$$

Among them, if the value of θ is equal to 1, $S^-=S^+=0$,the decision-making unit is valid for DEA; if the value of θ is equal to 1, $S^- \neq 0$ or$S^+ \neq 0$, the decision-making unit is weakly valid for DEA; if the value of θ is less than 1, the decision-ma king unit is not valid for DEA.

2.3 Data Sources and Original Data

The data comes directly from the 2020-2017 statistical yearbooks of cities and the statistical yearbooks of the provinces where the cities are located.

The original data is as follows:

Table 1 Logistics Industry Practitioners1

Logistics industry practitioners				
Unit: Ten thousand people	2019	2018	2017	2016
Yangtze River Delta				
Shanghai	93.76	89.52	89.39	89.73
Nankin	10.4807	12.6779	14.2297	14.3217
Wuxi	8.79	8.78	8.78	8.75
Changzhou	1.5519	1.9137	1.8661	1.9523
Nantong	2.8027	2.4622	2.6641	2.849
Yangzhou	2.0270	1.7543	2.3080	2.4267
Zhenjiang	1.2494	1.2826	1.2377	1.2521
Hangzhou	13.1066	15.8008	14.3327	14.2602
Ning Po	6.924	6.8091	6.1473	5.8832
Suzhou	9.0950	8.6347	7.3206	7.1669
Jiaxing	6.51	6.11	7.8000	7.66
Huzhou	1.2839	1.3707	1.2358	1.2152
shaoshing	1.97	1.31	1.4600	1.62
Zhoushan	1.8026	2.07	1.86	3.62

Table 2 Actual Road Kilometers At the End of the Year2

	Actual road kilometers at the end of the year			
Unit: km	2019	2018	2017	2016
Shanghai	13045	13106	13322	13292
Nankin	10182	10636	11324	11211
Wuxi	7591	7576	7749	7731
Changzhou	8962	9331	9200	9031
Nantong	19246	19005	18754	18427
Yangzhou	9726.38	9729.92	9610.43	9546.36
Zhenjiang	7321	7255	7443	7354
Hangzhou	16667	16520	16424	16210
Ning Po	11375	11295	11236	11248
Suzhou	11817.5	12173.2	12658.3	13297.5
Jiaxing	8288	8242	8140	8117
Huzhou	8065.31	8079.21	7958.25	7723.73
shaoshing	10222	10137	10136	10068
Zhoushan	1907.1	1921.8	1930.8	1948.4

Table 3 There Are Actual Civil Freight Vehicles At the End of the Year3

There are actual civil freight vehicles at the end of the year				
Unit: car	2019	2018	2017	
Shanghai	224170	215904	212316	200948
Nankin	143116	131289	116935	102101
Wuxi	112114	85789	78460	72354
Changzhou	88826	82546	78160	73904
Nantong	105424	96187	80859	76298
Yangzhou	32051	45120	45449	47150
Zhenjiang	36983	34979	32653	29963
Hangzhou	259746	248614	229038	202775
Ning Po	77622	68963	94033	66527
Suzhou	23157	23643	24159	24071
Jiaxing	20112	28770	28174	30003
Huzhou	12515	15690	13431	16483
shaoshing	107742	98263	78220	87920
Zhoushan	18806	17378	15595	13440

Table 4 Logistics Industry Freight Volume4

Logistics industry freight volume				
Unit: ten thousand pieces	2019	2018	2017	2016
Shanghai	346404.03	392736.71	368983.63	336142.29
Nankin	94670.15	84008.11	71422.19	54109.13
Wuxi	1865600	1176538	1040826	840200
Changzhou	27468.14	23343.54	19966.45	17442.65
Nantong	950299.7	74842	4640.29	3308.21
Yangzhou	17879.07	15910.1	13744.82	10907.19
Zhenjiang	14773.03	10376.77	8708.92	8038.37
Hangzhou	271237	267728	244388	214223
Ning Po	301986.54	227249.35	164529.55	108094.28
Suzhou	182366.7	134416.57	115322.82	98966.73
Jiaxing	7373	5264	4310.8	3344.34
Huzhou	4795	4958	5092	5758
shaoshing	7453.19	3885.82	2779.46	3572.84
Zhoushan	1995.92	1645.2	1886.6	1659.87

3. Empirical Analysis

This paper uses DEAP2.1 software to analyze the input and output of fourteen cities in the Yangtze River Delta region, and the results include comprehensive technical efficiency, pure technical efficiency, scale efficiency and scale benefit. The comprehensive technical efficiency is a comprehensive evaluation of the multi-faceted capabilities of the decision-making unit; the pure technical efficiency evaluation is the production effect that can be achieved under a certain input; the scale efficiency reflects the government's policy direction in the next step. Input the obtained data into DEAP2.1 software to get the result as shown below:

Table 5 Overall Efficiency5

	overall efficiency			
	2019	2018	2017	2016
Shanghai	0.108	0.193	0.206	0.233
Nankin	0.042	0.051	0.047	0.046
Wuxi	1	1	1	1
Changzhou	0.056	0.091	0.09	0.093
Nantong	1	0.227	0.015	0.012
Yangzhou	0.039	0.068	0.05	0.047
Zhenjiang	0.04	0.06	0.059	0.067
Hangzhou	0.094	0.126	0.144	0.156
Ning Po	0.234	0.249	0.226	0.191
Suzhou	0.473	0.415	0.36	0.354
Jiaxing	0.022	0.013	0.012	0.01
Huzhou	0.023	0.027	0.035	0.049
shaoshing	0.012	0.022	0.016	0.023
Zhoushan	0.006	0.007	0.009	0.011

Table 6 Pure Technical Efficiency6

	pure technical efficiency			
	2019	2018	2017	2016
Shanghai	0.186	0.334	0.355	0.4
Nankin	0.051	0.071	0.069	0.064
Wuxi	1	1	1	1
Changzhou	0.159	0.215	0.211	0.2
Nantong	1	0.386	0.023	0.018
Yangzhou	0.068	0.19	0.089	0.078
Zhenjiang	1	1	1	1
Hangzhou	0.145	0.228	0.235	0.255
Ning Po	0.247	0.262	0.242	0.207

Suzhou	0.896	0.975	0.655	0.647
Jiaxing	0.05	0.024	0.018	0.014
Huzhou	1	1	1	1
shaoshing	0.021	0.265	0.071	0.071
Zhoushan	1	1	1	1

Table 7 Scale Efficiency7

	Scale efficiency			
	2019	2018	2017	2016
Shanghai	0.582	0.578	0.582	0.582
Nankin	0.83	0.712	0.582	0.709
Wuxi	1	1	1	1
Changzhou	0.352	0.423	0.428	0.466
Nantong	1	0.588	0.646	0.682
Yangzhou	0.573	0.356	0.567	0.6
Zhenjiang	0.04	0.06	0.059	0.067
Hangzhou	0.644	0.556	0.613	0.614
Ning Po	0.945	0.95	0.934	0.925
Suzhou	0.528	0.425	0.549	0.547
Jiaxing	0.438	0.567	0.642	0.681
Huzhou	0.023	0.027	0.035	0.049
shaoshing	0.593	0.083	0.226	0.325
Zhoushan	0.006	0.007	0.009	0.011

Table 8 Scale, Income8

	Scale, income			
	2019	2018	2017	2016
Shanghai	drs	drs	drs	drs
Nankin	drs	drs	drs	drs
Wuxi	/	/	/	/
Changzhou	irs	irs	irs	irs
Nantong	/	irs	irs	irs
Yangzhou	irs	irs	irs	irs
Zhenjiang	irs	irs	irs	irs
Hangzhou	drs	drs	drs	drs
Ning Po	irs	irs	irs	irs
Suzhou	irs	irs	irs	irs
Jiaxing	irs	irs	irs	irs
Huzhou	irs	irs	irs	irs
shaoshing	irs	irs	irs	irs
Zhoushan	irs	irs	irs	irs

In the charts of comprehensive efficiency, pure technical efficiency and scale efficiency, we firstly classify the overall efficiency and obtain the following results: 1: The comprehensive efficiency of the six cities of Shanghai, Changzhou, Hangzhou, Huzhou, Zhoushan, and Zhenjiang is declining every year. . 2: The overall efficiency of the four cities of Nanjing, Yangzhou, Ningbo, and Shaoxing showed an upward trend, but fluctuated occasionally. 3: The three cities of Nantong, Suzhou and Jiaxing are on the rise. The overall efficiency is the product of pure technical efficiency and scale efficiency. Therefore, let us combine the preliminary classification to look at pure technical efficiency and scale efficiency and get the following results:(1) Among the cities with declining comprehensive efficiency, the scale efficiency of Shanghai and Hangzhou is on the rise, while the pure technical efficiency is in the Downward trend. The point that limits the improvement of the overall efficiency of these two cities is pure technical efficiency. (2) The scale efficiency and technical efficiency of Changzhou, Huzhou, Zhoushan and Zhenjiang are in a downward trend, and these four cities need to simultaneously improve the scale efficiency and technical efficiency. (3) Among the four cities that are on the rise but with large fluctuations, Yangzhou's pure technical efficiency and scale efficiency are both in a downward trend. If the city wants to reduce the fluctuation, it also needs to simultaneously improve the pure technical efficiency and scale

efficiency. (4) Except for Yangzhou, the pure technical efficiency of the remaining cities decreased but the scale efficiency increased. Ningbo, Shaoxing, and Nanjing all need to improve their pure technical efficiency. (5) Among the three cities showing an upward trend, the scale efficiency of Suzhou, Jiaxing and Nantong is in a state of decline. Suzhou, Jiaxing and Nantong need to improve their scale efficiency if they want to keep their overall efficiency rising.

In the table of returns to scale, we found that the economies of scale of Shanghai, Hangzhou, and Nanjing are in a state of diminishing. First, we combine the original data: (1) Shanghai's logistics industry employees, actual freight vehicles, and logistics industry freight volumes are all in a state of diminishing returns. It is in a state of continuous increase, and the number of road kilometers at the end of the year is in a state of decline. (2) The number of employees in the logistics industry in Nanjing and the number of actual road kilometers at the end of the year are in a state of decline, and the actual freight vehicles and the freight volume of the logistics industry are in a state of increase. (3) The number of employees in the logistics industry in Hangzhou is in a state of decline. At the end of the year, the actual number of kilometers, the actual number of freight vehicles, and the freight volume of the logistics industry are all in a state of increase. Secondly, combined with the three charts of comprehensive efficiency, pure technical efficiency and scale efficiency, it is found that the pure technical efficiency of Shanghai, Nanjing and Hangzhou is in a state of decline, but the scale efficiency is in a state of increase. To sum up, the following results are drawn: (1) The pure technical efficiency of cities in the state of diminishing returns to scale is in a state of decline. (2) The number of kilometers of roads in Shanghai and Nanjing is in a state of decline among the cities with diminishing economies of scale. (3) Among the cities with diminishing economies of scale, employees in the logistics industry in Nanjing and Hangzhou are in a state of decline.

4. Policy Investment Recommendations

4.1 Local Governments Should Flexibly Increase or Decrease Certain Aspects of Investment or Policies According to Local Conditions

For example, the reduction of overall efficiency in Shanghai should improve its technical efficiency. Through the raw data, it can be found that the number of trucks and employees are increasing but the number of road kilometers is decreasing, so the government should focus on the planning and increase of road mileage. The overall efficiency of Hangzhou is also declining, but combined with the original data, it is found that the number of road kilometers, employees, and freight vehicles are all on the rise. Therefore, the government should focus on industrial upgrading and optimization in the next step.

4.2 The Government Should Establish Long-Term and Good Cooperative Relations with Enterprises to Jointly Improve Logistics Efficiency

The construction of transportation infrastructure is not only an increase in the number of road kilometers, but also an increase in people and vehicles. People and vehicles cannot rely solely on government policies and investments, but should also involve enterprises. The government attracts enterprises through policies, and enterprises enter it to recruit relevant practitioners and increase the purchase of vehicles. For cities such as Suzhou, Nantong, and Jiaxing that need to increase scale efficiency, relevant departments are in urgent need of policies to attract enterprises and then attract related employees. Finally, it can increase its scale efficiency to achieve the purpose of prompting comprehensive efficiency.

4.3 Cities Should Cooperate with Each Other to Improve the Road Network.

The first two suggestions are both aimed at one city, but the Yangtze River Delta as a whole should benefit from each other and develop together. Therefore, for the construction of transportation infrastructure such as highways and railways, each city should propose a long-term cooperative relationship to jointly improve the highway and railway network in the Yangtze River Delta region. Urban agglomeration means the stratification of industry, manpower, and capital, and

it is particularly important to promote the stratification of industry, manpower, and capital so that cities can better coordinate the development of transportation infrastructure.

5. Conclusion

This paper uses the BCC model in DEA to conduct a simple analysis of the logistics efficiency of 14 cities in the Yangtze River Delta region, and finds that the increase in transportation infrastructure construction does not necessarily improve the logistics efficiency of a city or region, because logistics efficiency is also affected by capital investment, The quality of personnel, management level and other aspects of the impact. However, the reduction of transportation infrastructure will definitely lead to the reduction of logistics efficiency. For example, in Shanghai's data, the actual number of road kilometers at the end of the year has continuously decreased. Although personnel, vehicles, and freight are all rising, the overall efficiency is declining. . Through the data collected in the “Statistical Yearbook” of each city, it is found that there is a serious siphon phenomenon in the Yangtze River Delta region rather than a balanced stratification of industries, capital and human resources. In some of the prefecture-level cities, the number of employees in the logistics industry continues to decrease, and the decrease in personnel also leads to the reduction of vehicles and roads. A typical representative is Huzhou. Therefore, cities should not only focus on the investment and construction of transportation infrastructure to improve logistics efficiency, but also pay attention to the introduction of talents and capital. Only by improving in all aspects can pure technical efficiency and scale efficiency be improved so as to improve overall efficiency and then logistics efficiency. Efficient logistics as the foundation can enable the Yangtze River Delta, one of the core engines of China's economic development, to play its greatest role in leading China's economy to realize industrial transformation and upgrading.

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