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Logistics Spatial Layout Analysis of the New Yangtze River Delta Based on Traffic Superiority

Jin_Fenghua*, Yang_Baimei, Xu Xu
School of Business, Shanghai Dianji University, Shanghai,China
**Correspondent Author: 272054384@qq.com*

ABSTRACT

In this paper, we study 26 cities of New Yangtze River Delta. On the basis of redefinition and analysis on the regional logistics capability with factor analysis method, we extract three factors: logistics economic scale, per logistics demand and agricultural output. Then we analyze the logistics spatial layout of the New Yangtze River Delta with Nature breaks method. The results indicate that Shanghai has absolute advantage in the new agglomeration, spatial layout impacts on logistics economic scale and per logistics demandobviously; the regional logistics has formed approximate vertebral structure; the traffic superiority reflects traffic infrastructure system development more comprehensively; the 8 cities in Anhui Province show underperforming status and should strengthen overall development based on the capital energy.

Key words: Region development; Logistics capability; New Yangtze River Delta; Nature breaks method; Traffic superiority

1. INTRODUCTION

As an important part of regional economic system, regional logistics provides irreplaceable supporting role for regional economic development. For developing scale effect of regions, urban agglomerations are widely concerned as regional carriers. To cultivate higher development level of economic growth poles, NYRD (New Yangtze river delta)formally passed “Yangtze River Delta urban agglomeration development plan” in May 2016, and develop26 cities which consist of Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yancheng, Yangzhou, Zhenjiang, Yangzhou, Taizhou(in Jiangsu Province), Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing, Jinhua, Zhoushan, Taizhou(in Zhejiang Province),Hefei, Wuhu, Ma’anshan, Tongling, Anqing, Chuzhou, Chizhou and Xuancheng.

In the researches of regional logistics, Ma Ming et al. compared the logistics industry efficiency between three provinces of the Yangtze River Delta and three provinces of northeast China by three-stage SBM model, to improve the overall efficiency of logistics industry[1]; Liang Zijing constructed Cobb Douglas function model with data of logistics GDP, fixed asset investment, number of employed persons in logistics related industries and so on, analyzed the factor input impact on Jiangsu logistics layout and verified factor bias of logistics development [2]; Gao Ying constructed optimized models based on scale effect, network cost and logistics service time for regional logistics network in Beijing-Tianjin-Hebei, solved the model with genetic algorithms [3]; Lu Bo et al. forecasted the static logistics flow and dynamic logistics flow for Erdos Si with regional gravity model, and identified the major industrial activities that associated with large number of cargo flows [4]; Song Ling et al. evaluated the regional logistics competitiveness of provincial regions in China with factor analysis method and clustering analysis method [5]; Zhou Tai et al. explored regional logistics capability for western China, quantitatively analyzed the capability with TOPDIS decision-making method and proposed improvement suggestions [6]; Zou Xiao et al. calculated the relation between industrial structure optimization with regional logistics capability by principal component analysis, the results indicated the relation became strong but there were still lags [7] ÿQi Shengda et al. analyzed the developing level of Silk-road Economic Belt with GINI coefficient, location quotient and gravity model, found that the characteristics of the spatial layout is significantly different in China, presented multi-center hierarchical diffusion pattern and so on [8]; Hou Haitao analyzed the coupling relationship between regional logistics and regional economics with geographic relation rate, geographic concentration degree, geographic coupling degree, and showed dynamic development status [9]; Cao Bingru et al. described the regional logistics from comprehensive development, logistics & market supply and demand, logistics infrastructure, analyzed hub-and spoke network of Yangtze River Delta which with the cores such as Shanghai logistics metropolitan, Nanjing logistics metropolitan and Hangzhou logistics metropolitan [10].

The foreign researches focused on urban logistics planning, optimization of logistics network, the impact of logistics measures on regional traffic network and so on [11-14]. The description of regional logistics in domestic and foreign researches all inferred the impact of traffic facilities, but limited to the mileage of highway and waterway. The operation of logistics system not only rely on these facilities, but the moving ability which generate from these facilities, similar with the "traffic superiority". The expansion of NYRD will also impact on the original layout of 16 cities. Therefore,the "traffic superiority" is introduced into regional logistics description, to analyze the layout change of regional logistics space, which provide evidences for promoting the coordinated development and urban agglomeration effect of NYRD.

2. DATA SOURCE

According to the author's previous researches about regional logistics capability,we obtain the description of regional logistics. That means the logistics service capability for supporting regional economic development with capital investment, road network construction, human resources and information platform et al. [15].Limited to the existing researches and data availability, the regional logistics capability index system is constructed from logistics scale, economic foundation and traffic superiority, as shown in table 1.

Table 1 Index system of regional logistics capability

Item	Sub-Item
Logistics Scale	Freight volume (X_1), Number of employed persons in logistics related industries(X_2), GDP of logistics industry (X_3), Possession of vehicles (X_4)
Economic Foundation	GDP (X_5)0Per capita GDP (X_6),Household consumption level(X_7), Industry GDP (X_8), Agricultural GDP (X_9), Wholesale and Retail Trades (X_{10}),Number of internet users (X_{11})
Traffic Superiority	Traffic network density (D), Traffic artery proximity (R), Accessibility (N), Location advantage (Z)

The traffic superiority in regional logistics capability index refers to the superiority of regional traffic facilities and supporting capability to economic activities, including the development level, supporting capability and spatial disparity of traffic facilities [16][17].We describe the traffic superiority from traffic network density, traffic artery proximity, accessibility and location advantage.

(1) Traffic network density D_i reflects the density of regional traffic infrastructure, which is determined by the proportion of road length to regional land area. Larger value means higher density of traffic infrastructure network. In the traffic infrastructure system of NYRD, the highways contribute to the elements flow among cities obviously. Hence, relevant data of highway network are used toreflect traffic network density.

(2) Traffic artery proximity R_i reflects the proximity to railway hubs, trunk highway, ports, airports and so on. In this paper, the analysis is divided into two dimensions, highway and railway.The analysis of highway artery proximity combines with the distribution trend of inter-city highway network, takesthe administrative center of each city as the landmark centers, and calculates the sum distances to highway entrances along the routes from the city center to other cities in the NYRD. The proximity of railway trunk line will be calculated by the road distance from the city center to the railway hub.

(3) Accessibility N_i reflects the convenience of traffic network in regions and between regions. For keeping a uniformcaliber to analyzed the accessibility, we also analyze the accessibility from highway and railway. We calculate the minimum highway driving time to describe the accessibility, with the network analysis function of ArcGIS. In consideration of railway station grade has a great influence on the service level, it is necessary to give weight to each railway station to calculate average travel time.

$$N_{ti} = \frac{\sum_{j=1}^{n}(T_{tij} P_j)}{\sum_{j=1}^{n} P_j} \quad (1)$$

In formula (1), N_{ti} is the sum of the shortest travelling time of railway between city *i* with other cities in the NYRD, T_{tij} is the shortest travelling time between city *i* with city *j*, P_j is the rank weight of railway station in city *i*.

Based on the city administrative rank, railway passenger volume, freight volume and other related data, the weights of railway stations in the NYRD are set in table 2.

Table 2 Rank and weight of railway stations in the NYRD

Rank	City	Weight
1	Shanghai, Hangzhou, Ningbo, Nanjing, Hefei	0.5
2	Changzhou, Jiaxing, Jinhua, Shaoxing, Wuxi, Suzhou	0.3
3	Nantong, Yancheng, Yangzhou, Zhenjiang, Taizhou(in Jiangsu province), Huzhou, Taizhou(in Zhejiang province), Wuhu, Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou, Xuancheng	0.2
4	Zhoushan	0

(4) Location advantages Z_i reflects the average traffic distance for each city with other cities in the NYRD. We classify the central cities into regional center (Shanghai) and provincial centers (capital cities). Because ofthe different rank impact on surrounding cities, the weight should be set on travelling distance between each city with different central cities, as shown in table 3.

Table 3 Weight of location advantages

City rank	Distance（km)	Weight
Regional central city	0-100	2.0
	100-200	1.2
	200-300	0.6
	300-400	0.3
	>400	0.1
Provincial central city	0-100	0.6
	100-200	0.3
	>200	0.1

(5) Traffic superiority S_i. Combine the four index mentioned above with formula (2), S_i is the traffic superiority of city *i*, then ±,²,³and´ are the weights for four index.

$$S_i = \alpha D_i + \beta R_i + \gamma N_i + \delta Z_i \quad (2)$$

3. DEMONSTRATION OF LOGISTICS SPATIAL LAYOUT OF THE NYRD

Combined with the related data according to table 1,we analyze the logistics capability of the NYRD with factor analysis methodTo retain the data integrity andthe irreplaceable effects of the four index of traffic superiority, we set equivalent weight to the four index to describe traffic superiority. From the results of factor analysis, the kaiser-meyer-olkin is 0.762 and Bartlett's sphericity value indicates that the data is suitable for factor analysis. After extracting three factors, variance cumulative value reaches 85.521%.The rotated component matrix of each factor (converged after 3 iterations) are shown in table 4. Infactor F_1, the loadings of X_2, X_3, $X_5$and X_{10} are prominent, so name F_1 as logistics economic scale.Infactor F_2, the loadings of X_7 and X_6 are prominent, so name F_2 as per logistics demand. In factor F_3, the loading of X_9 is prominent, so name F_3 as agricultural output factor.

Table 4 Rotation component matrix of each factor

Index	Factor loading			Index	Factor loading		
	F1	F2	F3		F1	F2	F3
X2	0.97	0.021	-0.085	X10	0.921	0.355	0.033
X3	0.967	0.196	-0.013	X9	0.167	0.04	0.899
X5	0.926	0.361	0.006	S	0.511	0.166	-0.478
X6	0.358	0.842	-0.096	X1	0.873	-0.078	0.051
X7	0.033	0.901	0.016	X11	0.887	0.426	0.085
X8	0.755	0.36	0.012	X4	0.764	0.564	0.134

The values of three factors and scores of 26 cities are shown in table 5.We cluster the values of F with software SPSS into four types, and then input the F to software ArcGIS with nature breaks methodand classify F as figure 1.

Table 5 Factor scores data

City	F1	F2	F3	F	City	F1	F2	F3	F
Shanghai	4.433	-0.807	-0.917	2.226	Huzhou	-0.575	0.228	-1.013	-0.365
Nanjing	0.617	1.117	0.305	0.603	Shaoxing	-0.645	0.89	-0.04	-0.18
Wuxi	-0.177	1.518	-0.505	0.169	Jinhua	-0.598	0.535	0.107	-0.214

Table 5 Contd...

Changzhou	0.097	-0.062	-0.943	-0.044	Zhoushan	-0.903	0.468	0.359	-0.375
Suzhou	0.663	2.273	0.103	0.849	Taizhou	-0.387	0.182	1.216	-0.069
Nantong	0.22	-0.039	1.35	0.237	Hefei	0.352	-0.566	0.566	0.131
Yancheng	0.055	-0.813	3.289	0.16	Wuhu	-0.186	-0.812	-0.672	-0.332
Yangzhou	-0.194	-0.008	-0.048	-0.114	Ma'anshan	-0.622	-0.431	-1.11	-0.536
Zhenjiang	-0.52	0.621	-1.105	-0.262	Tongling	-0.647	-0.904	-0.908	-0.63
Taizhou	-0.136	-0.183	0.071	-0.107	Anqing	-0.286	-1.493	0.161	-0.453
Hangzhou	0.485	1.264	0.514	0.578	Chuzhou	-0.121	-1.714	0.393	-0.386
Ningbo	0.382	0.859	1.006	0.482	Chizhou	-0.566	-1.399	-0.533	-0.653
Jiaxing	-0.322	0.49	-1.308	-0.197	Xuancheng	-0.419	-1.216	-0.338	-0.516

Figure 1 Classification figure of regional logistics capability scores

From the results, it is shown that the rank of F is similar with the one when there are 16 cities in previous Yangtze River Delta.Shanghai still occupies the central status of the NYRD, and shows obvious gaps with other cities. Nanjing and Hangzhou rank the third and the fourth separately, however, Hefei as a provincial city only ranks the ninth. Though it is not an administration center, Suzhou ranks second due to its spatial advantage and own economic development capability.

The logistics system of NYRD has formed approximate vertebral body from the spatial layout, which takes Shanghai as the apex and takes Suzhou, Nanjing, Hangzhou and Ningbo as four fulcrums. When we take the north-south line of Nanjing as the axis, the logistics capability of the cities locate on both sides of the axis are contrast obviously.In the eight cities belonging to Anhui, only Hefei can rank the second grade, and the other cities rank the third and the fourth grade.

Finally,we analyze the three factors as follows: (1) Compared with F, F_1 distributes more balanced. Nantong plays its spatial advantage that closes to Shanghai, ranks the second grade for logistics economic scale sequence along with Suzhou and Ningbo. Hefei obtains improved environmentcomparedwith its F status, but the logistics capability of the cities in Zhejiang province have been weakened. (2) F_2 of Shanghai has lost the prominent advantage, andSuzhou, Wuxi and Hangzhou rank the first grade.The cities which in the same grade show agglomerate in space. The cities get lower grade with farther distance to agglomeration center. (3) F_3 of Yancheng has a prominent performance, reflect the logistics capability of Yancheng driven by agriculture development. Nantong, Ningbo and Taizhou(in Zhejiang Province) in second grade also fully play the logistics service capability for agricultural output.

4. CONCLUSION

The paper constructsregional logistics capability from logistics scale, economic foundation and traffic superiority, and analyzesthe logistics spatial layout of NYRD combined with factor analysis method, clustering analysis method, nature break method. Conclusions are as follows:

(1) We extract three factors with factor analysis method, the F_1 of Shanghai is consistent with previous researches conclusions, Suzhou, Ningbo and Nantong rank second grade. The cities in same grades of F_2show obvious agglomeration in space, the F_3 of Yancheng ranks No.1. The spatial factors impact on the spatial layout more obviously, which indicates more logistics energy can be absorbed when adjacent to the city which get stronger logistics capability, and the original geographical disadvantage can be improved by optimization of traffic network. Different city should develop the logistics capability of the leading industry according to their own characteristics of industrial structure, to promote comprehensive logistics capability.

(2) The conclusion of factor scores with traffic superiority has formed an approximated vertebral body,which is different with previous researches. Spatialneighborhood between Shanghai and Suzhou, contributes to play win-win co-operation effect and the pole energy andto form more growth poles.

(3) Traffic superiority comprehensively reflect the capability required by logistics operation of urban agglomeration. Because there is no railway transportation in Zhoushan city the result shows obvious weak status in traffic superiority.However, other factors drive the logistics capability development of Zhoushan rather than traffic conditions.

(4) Though Hefei city is the capital of Anhui province, it does not rank front sort in the NYRD. At the same time, the 8 cities of Anhui province perform weakly.Therefore, they should absorb more energy and opportunity from central city of urban agglomeration, to enhance radiation ability of the capital and promote the development of other cities in Anhui province.

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