Study on Synergetic Development of Regional Logistics and Regional Economy in China's Yangtze River Delta

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Abstract

Based on theoretical analysis this paper studies the synergetic development of logistics system and regional economy system in China's Yangtze River Delta and aims to explore and measure the synergetic development degree between the two systems by using the coupling degree model. The result shows between 2001 and 2016, the development level of regional logistics industry and economy in China's Yangtze River Delta showed a significant upward trend. The order degree of regional logistics system is lower than the order degree of regional economic system, which means the development of regional logistics cannot effectively promote the development of regional economy.

Keywords: Regional logistics system, Regional economic system, synergetic development

Introduction

The development of regional logistics has become an important indicator of the regional economic development. Efficient and modernized regional logistics is the foundation of regional economy, and also one of the core measures of the level of regional modernization. Regional logistics plays an important role in promoting the transformation of regional economic growth mode, pushing regional industrial structure change, increasing regional economic competitiveness and accelerating the process of regional economic integration. Meanwhile, the development of regional economy can also promote the rapid development of regional logistics industry (Capello, 2009; Hausman, 2013; Xie, 2015; Centobelli, 2017).

How to synergize the development of regional logistics industry and regional economy in a coordinated and orderly manner, so as to bring great impetus to the development of social economy, is a major challenge to policy makers, industry and academia. Thus attentions should be paid to the research on synergetic development of regional logistics industry and regional economy system (Lan, 2018).

In this paper, based on the complex system theory and coupling degree model, we analyzed the relationship of regional logistics and regional economy and studied the synergetic development of the two systems in Yangtze River Delta. The results show that there is a significant correlation between the two systems. The order degree of regional logistics system increasing by 1% can increase the order degree of the regional economic system by 0.9361%. The coupling coordination level between the two systems in the Yangtze River Delta has been continuously improved and experienced a transition from an unstructured to a coordinated development in its logistic system and economic system. But the order degree of regional logistics system is obviously lower than the order degree of regional economic system. So, the regional logistics should turn to the strategies that focused on higher quality, better efficiency and lower cost.

Literature review

Synergetic development between regional logistics system and regional economic system plays a very important role in stimulating the economy growth of a region (Skjott-Larsen, 2003; Hausman, 2013; Sainz et al., 2015; Lan, 2017).

Based on the perspective of global logistics network and supply chain conception, Hausman et al.（2013）carry out a quantitative analysis of the relationship between the micro performance indicators of logistics service and the global bilateral trade. Skjott-Larsen（2003）conducts an empirical study on the relationship between logistics industry and regional economy based on the DECD model. Sainz et al. (2013) use the input output method to analyze the role of logistics infrastructure investment in promoting economic development of Arogon region in Spain. Pablo et al. (2016) use the production function and the panel data of 34 countries from 2007 to 2012 to study the impact of logistics and information technology on the world output technical efficiency by using the random frontier analysis method. Lan (2017) examined the interactions between metropolitan logistics and economy by building evaluation index systems for metropolitan logistics and economy by taking five metropolises in China, namely Beijing, Shanghai, Guangzhou, Chongqing and Tianjin as the research focus.

On the other hand, previous research also focused on how to effectively promote the synergetic development of regional logistics system and regional economic system. Bolumole et al. (2015) explore the deliberate governance efforts of regional economic development agencies and the communities they support in their attempts to exploit location-specific logistics assets to deliver economic productivity gains. Bensassi et al. (2015) point out that geographical factors and transport infrastructure are two of the key determinants that influence regional competitiveness. Their study shows that the distribution and capacity of logistics facilities in a region, as well as the number of private operators and their degree of specialization, all play an increasingly important role in the synergetic development of regional logistics system and regional economic system. Previous studies also suggest that logistics industry clusters is also play a very important role on the synergetic development of regional logistics and regional economy. Rivera et al. (2016) hypothesize that within the context of logistics clusters, further agglomeration within the more defined logistics parks and the availability of training opportunities will enhance the synergetic development. Centobelli et al. (2017) argue that logistics sustainability plays a critical role on the synergetic development of regional logistics and regional economy. Hylton et al. (2018) analyses the agglomeration economies' influence on logistics clusters' growth and competitiveness, their study is clearer that regional agglomeration of economy can obviously enhance the coordination of regional logistics industry.

However, there are still some gaps in the literature. Firstly, the current research largely focus on the influencing effect of regional logistics on regional economy and fail to consider the reverse influence, let along the synergetic development between the two systems by suing quantitative methods. Secondly, the index of measurements and evaluations are not clearly identified. Most researchers still use the single indicator, such as the total investment of logistics infrastructure and GDP, to indicate the development level of regional logistics system and regional economic system. Finally, there are also some deficiencies in the research methods. These gaps should be filled to provide more comprehensive insights for the synergetic development of regional logistics system and regional economic system.

Methodology

Entropy method is an objective valuation method to determine the weight according to the size of information load of each variable, which can reduce the deviation caused by subjective factors (Pun, 2004). The weight of each variable can be determined by the influence of each variable's variation on the whole system. The more it varied the more weight it will carry.

The main calculation steps are as follows: Construct the judgment matrix $P = (a_{ij})_{m\times n}$ and standardize it. And a_{ij} is normalized value of x_{ij}. Calculate the proportion (u_{ij}) of variable (a_{ij}). $u_{ij} = a_{ij}/\sum a_{ij}$. Calculate the entropy value (e_j) of variable (a_{ij}). $e_j = -k\sum p_{ij} ln p_{ij}$. Calculate the difference coefficient(g_j) of variable (a_{ij}). $g_j = 1 - e_j$. Calculate the weight (w_j) of the jth indicator. $w_j = \frac{g_j}{\Sigma g_j}, (j = 1,2,3 \ldots m)$.

The order degree of the subsystem

1. Order parameter variables

According to Synergy theory (Meisel and Mattfeld, 2010; Li et al., 2010; Kumar and Rodrigues, 2017), order parameter plays a leading role in the evolution and development of system, and there is competition and cooperation among the order parameters, so that the evolution process of composite system from disorder to order is promoted.

2. Standardization of order parameter

Because the data unit of the order parameter is different, it is necessary to standardize the order parameter for the convenience of calculation. In this paper, the method of max-min standardization is adopted, and the formula is as follows:

Positive index： $a_{ij} = \frac{X_{ij} - \min_j}{\max_j - \min_j}$ （1）

Negative index： $a_{ij} = \frac{\max_j - X_{ij}}{\max_j - \min_j}$ （2）

In order to avoid the limit condition of [0, 1], the Max and the Min are 1.01 times of the maximum value of indicator J and 0.99 times the minimum respectively. X_{ij} and a_{ij} are the original value and the standard value of the order parameter of the subsystem (regional economic system and regional logistics system), $0 \le a_{ij} \le 1$.

The calculation of the order degree of the subsystem

As for the order parameter X_{ij} in subsystem X, the greater the value of $u_{ij}(t)$, the greater the contribution of it to the development of the system. In a subsystem, the degree of contribution of different order parameters to the order degree of system is different. We can get the order degree of subsystem by weighting sum of order parameter. It is assumed that the order of the subsystem at t time is $u(t)$, and its calculation formula is as follows:

$u_x(t) = \sum_{i=1}^{n} w_j u_{ij}$ （3）

The w_j is the weight of the subsystem order parameter X_{ij}, and u_{ij} is the standard data. Since the normalization of order parameters is [0, 1], the range of value after weighting is also within the [0, 1] interval.

Measurement of intersystem coupling level

Suppose that X and Y represent the subsystems of a large system composed of system X and system Y. At time t, the order degree is $u_x(t)$ and $u_y(t)$ respectively. The coupling degree model of two systems is established by using the concept of capacity coupling and the capacity coupling coefficient model in Physics (KUAH, 2005; Chen and Ji, 2017).

$CI = \{(u_x(t) * u_y(t))/(u_x(t) + u_y(t)) * (u_x(t) + u_y(t))\}^{1/2}$ （4）

Formula (4) only reflects the degree of coupling between the systems, and to a certain extent, it embodies the relative static coordinated development state between the systems. In practical application, the index only is not enough. Therefore, consideration should be given to the system growth level, so the comprehensive growth level of the system is added in formula (4) to get formula (5), in order to characterize the dynamic coupling between the system development levels, namely the coupling synergy degree SD (t).

$SD(t) = (CI \times T)^{1/2}$ $T = \alpha u_x + \beta u_y$ （5）

In formula (5), T represents the comprehensive coordination index of the two subsystems, reflecting the contribution of the overall level of development of the two systems to the degree of synergy. α and β are undetermined coefficients, which represent the contribution coefficient of regional economic system and regional logistics system respectively. The development of the regional logistics system can promote the development of regional economic system, but the regional logistics system is not the only contributor of the regional economic system. Therefore, on the basis of previous research (Li et al., 2010; Bolumoleet al., 2015; Guo and Han, 2015; Campos, 2016; Lan, 2017), the α and β values are assigned as 0.6 and 0.4 respectively, that is, the weight coefficient of the regional economic system is 0.6, and the weight coefficient of the regional logistics system is 0.4.

Criteria for evaluating the coupling synergy degree

The coupling synergy degree is divided into 10 grade intervals. Each interval represents a synergy grade, and each level corresponds to a coordination state, forming a continuous ladder, which can more directly reflect the coupling development degree between the two systems. The specific criteria are shown in table 1.

Table 1 - Criteria for evaluating the coupling synergy degree

Orders	Interval	Synergy level (Disorders)	Orders	Interval	Synergy level (Coordination)
1	0～0. 1	Extremely disorders	6	0. 5001～0.6	Basic coordination
2	0. 1001～0. 2	Serious disorders	7	0. 6001～0. 7	Primary coordination
3	0. 2001～0. 3	Moderate disorders	8	0. 7001～0. 8	Intermediate coordination
4	0. 3001～0. 4	Mild disorders	9	0. 8001～0. 9	Good coordination
5	0. 4001～0. 5	On the verge of disorders	10	0.9001～1	High quality coordination

Source of data

The current research takes the Yangtze River Delta as the research object, and the data in this paper are from the statistical yearbook of Jiangsu province, Zhejiang province, Anhui province, Shanghai municipal and China. As these data are published by the statistical department of the central government and the local government of China, the authenticity, integrity and authority of these data can be well guaranteed. Therefore, the source of data used in this paper is reliable, and the quality of data is guaranteed, which can meet the needs of our research.

Empirical results and discussion

In this section, based on the literature review, we will construct the evaluation indicators of the synergetic development of the logistics industry and the regional economy in Yangtze River Delta. The regional logistics system is measured from three aspects: logistics industry infrastructure, logistics industry development scale, and logistics industry development potentials. The regional economic system is also measured from three aspects, including the total economic volume, economic structure, and economic performance. Each evaluation dimension has several specific indicators and table 2 shows these indicators and the evaluation dimensions.

The weight coefficient of each indicator is calculated by entropy weight method mentioned in section 4, shown in the last column of table 2. In the regional economic subsystem, the entropy weight value of the Total Retail Sales of Consumer Goods is the largest (0.095), and the entropy weight value of the Year-end Resident Population is the smallest (0.033). Among the indicators of the logistics subsystem, the entropy weight value of Express service volume is the highest (0.170), and the entropy weight value of the Students Enrollment by Institutions of Higher Education is the lowest (0.027). As entropy value is a measure of the degree of disorder of a system, it does not represent the importance of the indicator in the subsystem, but only illustrates the extent to which the indicator provides more or less effective information.

Table 2 - The evaluation indicators system and its weights on the coupling model

First order	Second order	Third order	symbol	type	Weight
indices of regional economic system	indices of total economic volume (0.351)	Gross Domestic Product （100 Million RMB）	X_1	+	0.079
		Total Retail Sales of Consumer Goods（100 Million RMB）	X_2	+	0.095
		Total Value of Foreign Trade Imports and Exports（100 million USD）	X_3	+	0.056
		Total Investment in Fixed Assets（100 Million RMB）	X_4	+	0.088
		Year-end Resident Population（10 000 persons）	X_5	+	0.033
	indices of total economic structure (0.245)	Gross Output Value of Agriculture (100 Million RMB）	X_6	+	0.086
		Secondary Industry Added Value（100 Million RMB）	X_7	+	0.069
		Tertiary Industry Added Value（100 Million RMB）	X_8	+	0.09
	indices of total economic performance (0.404)	Per Capita GDP（RMB）	X_9	+	0.071
		General Budgetary Revenue（100 Million RMB）	X_{10}	+	0.086
		Prime Operating Revenue of Industrial Enterprises above the Set Scale（100 Million RMB）	X_{11}	+	0.072
		Urban Household Consumption Level（RMB）	X_{12}	+	0.081
		Rural Household Consumption Level（RMB）	X_{13}	+	0.094
indices of regional	indices of logistics industry infrastructure (0.337)	Operation Mileage of Railway（km）	Y_1	+	0.052
		Operation Mileage of Highway（km）	Y_2	+	0.049
		Total Length of Mail Routes (10 000 km)	Y_3	+	0.084
		Freight Trucks（10 000 vehicles）	Y_4	+	0.051
		Postal outlets (unit)	Y_5	+	0.101
	indexes of logistics industry	Freight Traffic Volume（10 000 tons）	Y_6	+	0.053
		Turnover Volume of Freight Traffic（100 million tons·km）	Y_7	+	0.050

logistics subsystem	infrastructure (0.385)	Total Volume of Postal and Telecom Business (100 million RMB)	Y_8	+	0.054
		Express service volume（10000 pieces）	Y_9	+	0.170
		Gross Output Value of Logistics（100 Million RMB）	Y_{10}	+	0.058
	indices of logistics industry infrastructure (0.278)	Investment in Fixed Assets of Logistics（100 Million RMB）	Y_{11}	+	0.058
		Three types Patent Applications (item)	Y_{12}	+	0.083
		Students Enrollment by Institutions of Higher Education (10000 persons)	Y_{13}	+	0.027
		Internet Netizen (10000 persons)	Y_{14}	+	0.057
		Mobile telephone switch capacity (10000 doors)	Y_{15}	+	0.053

Note: "+" is a positive indicator, and "-" is a negative indicator. The selected variables and value are resourced from Shanghai Statistical yearbook, Jiangsu Statistical yearbook, Zhejiang Statistical yearbook, Anhui Statistical yearbook and China Statistical Yearbook.

According to the evaluation indicators and the coupling model that discussed in section 3, we calculated the order degree (Ux, Uy) of each subsystem and the absolute deviation (Ux- Uy), the coupling degree (CI) and the coupling synergy degree (SD (t)) between the regional logistics subsystem and the regional economy subsystem in the Yangtze River Delta, by using formula 3, 4 and 5. Furthermore, in accordance with the criteria for evaluating coupling synergy degree, the coupling coordinated development level of the regional logistics and the regional economy in Yangtze River Delta is evaluated. The results are shown in table 3.

Table 3 - Coupling synergy degree and the evaluation between the two subsystems

Years	U_E	U_L	U_E vs U_L	U_E - U_L	CI	SD (t)	Coupling synergy degree
2001	0.0042	0.0053	$U_E < U_L$	-0.0021	0.4894	0.0496	Extremely disorders
2002	0.0242	0.0292	$U_E < U_L$	-0.0049	0.4979	0.1142	Serious disorders
2003	0.0561	0.0534	$U_E > U_L$	0.0027	0.4998	0.1658	
2004	0.1055	0.0737	$U_E > U_L$	0.0318	0.4921	0.2136	Moderate disorders
2005	0.1485	0.1136	$U_E > U_L$	0.0350	0.4955	0.2582	
2006	0.1990	0.1748	$U_E > U_L$	0.0242	0.4990	0.3073	Mild disorders
2007	0.2667	0.2535	$U_E > U_L$	0.0132	0.4998	0.3615	
2008	0.3364	0.3114	$U_E > U_L$	0.0250	0.4996	0.4038	On the verge of disorders
2009	0.3765	0.3576	$U_E > U_L$	0.0189	0.4998	0.4294	
2010	0.4807	0.4347	$U_E > U_L$	0.0460	0.4994	0.4805	
2011	0.5948	0.4862	$U_E > U_L$	0.1086	0.4975	0.5237	Basic coordination
2012	0.6629	0.5695	$U_E > U_L$	0.0934	0.4986	0.5585	
2013	0.7447	0.6531	$U_E > U_L$	0.0917	0.4989	0.5944	
2014	0.8276	0.7391	$U_E > U_L$	0.0885	0.4992	0.6289	Primary coordination
2015	0.8976	0.8628	$U_E > U_L$	0.0348	0.4999	0.6646	
2016	0.9840	0.9759	$U_E > U_L$	0.0081	0.5000	0.7003	Intermediate coordination

It can be seen in figure 1, during the period of 2001-2016, the development level of logistics subsystem and regional economy subsystem in China's Yangtze River Delta has been greatly improved, and the order degree of the two subsystems has increased from 0.0042 and 0.0053 in 2001 to 0.9840 and 0.9759 in 2016, respectively. The average annual growth rate was 47.76% and 45.10%, respectively.

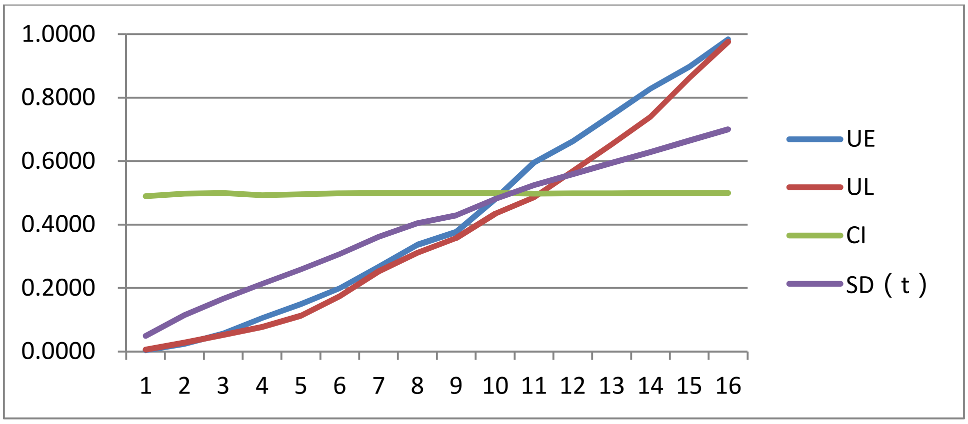

Figure 1 - Degree of order, coupling degree and coupling synergy degree of the subsystems

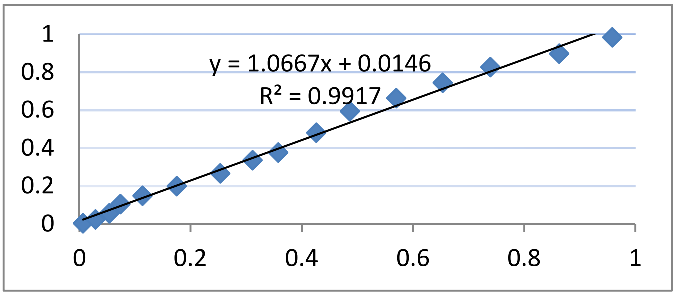

Figure 2 - Linear fitting of the degree of order value of the two subsystems

We conducted a correlation analysis of the order degree value of the two subsystems and found that the Person correlation coefficient between them is as high as 0.9951, which shows a significant correlation. According to the linear fitting results shown in Figure 2, we can see that under this circumstance of the fitting accuracy R^2 is up to 0.9904, the order degree's value of the regional logistics industry increases by 1%, which can increase the order degree's value of the regional economic system by 0.9361%. This shows that there is a strong correlation between the regional logistics system and the regional economic system in the Yangtze River Delta. Thus, there is a strong coupling interaction relationship, which suggests the orderly development of the regional logistics system plays a very strong role in promoting the steady growth of the regional economy.

The coupling synergy level of the two systems has gradually changed from a maladjustment stage (before 2010) to a coordination stage (after 2010). Hence, the year of 2010 is the demarcation point of the system coupling synergy degree. Before 2010, the synergy effect of regional logistics and regional economy is not strong, and the interaction between each other is weak. After 2010, the synergy effect of regional logistics system and regional economic system has been enhanced.

Nevertheless, the coupling synergy degree of the regional logistics system and the regional economic system has only reached and intermediate coordination state. For instance, the order degree of the regional logistics subsystem is larger than that of regional economy subsystem only in the first two years. In the next 14 years, the order degree of regional logistics subsystem is smaller than that of regional economy subsystem. Especially after 2009, the absolute deviation (UE - UL) of the order degree between the regional logistics subsystem and the regional economy subsystem has significantly increased, and this trend has not been alleviated until 2014. Between 2001 and 2008, the average value of the absolute deviation of the two systems' order degree is 0.0156, while between 2009 and 2016 the average value is 0.0612, which is 3.92 times bigger than between 2001 and 2008. This shows that the synergetic development degree and synergy level of the regional logistics subsystem in the Yangtze River Delta area still need to be improved. The local governments and the industry still need further input and investment to modernize the logistics industry. Initiatives may include speeding up the development of the regional logistics integration in the Yangtze River Delta region, improving the operational efficiency of the regional logistics system, and reducing the cost of logistics systems. This will eventually enhance the coupling synergy degree of the regional logistics subsystem and the regional economy subsystem to a higher level.

Conclusions

Based on the coupling synergy degree model, a quantitative analysis of the synergetic development of the logistics system and the regional economic system in the Yangtze River Delta from 2001 to 2016 was carried out in this paper. In the past 16 years, the coupling synergy degree between logistics industry and regional economy in the Yangtze River Delta has been increasing steadily, and the coupling synergy degree has shifted from a maladjustment stage to a coordination stage. Currently, the synergetic development level of the regional logistics and the regional economy in Yangtze River Delta are in the intermediate coordination stage. But the order degree of regional logistics subsystem is significantly lower than that of the regional economic subsystem. The development of the regional logistics system may not effectively promote the development of the regional economy, which can be a restriction on the development of regional economy. There are still some limitations and shortcomings in this paper, largely due to the limited access to large scale data. Future research is needed to verify the suitability of this approach using wider range of data and in different regional context.

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