Research on the Coupling Synergy Degree of the Coordinated Development of E-commerce and Logistics Industry in Jilin Province

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Abstract. Electronic commerce and logistics industry have a synergistic relationship of mutual restriction and mutual promotion. It is of great practical significance to measure the coupling synergy degree of the two industries, so as to find the way to promote the coordinated development of the two industries. According to the theory of "Synergy" and "Industrial Collaboration", the Information Entropy Value can be used to measure the level of the system synergy. This paper constructs the coupling synergy model of e-commerce and logistics industry. Based on the analysis of the development status of the two industries in Jilin Province, the development index system is used to measure the level of coupling synergy. It is concluded that in the past five years, the coordinated development state of the two industries in Jilin Province has been in the stage of uncoupling and near imbalance.

Keywords: E-commerce; Logistics Industry; Coordinated Development; Coupling Synergy Degree.

1. Introduction

The synergy theory of e-commerce and logistics industry is based on the theory of "industrial synergy" which is developed from the theory of "synergetics". In 1965, Igor Ansoff, an American strategic expert, clearly proposed the strategic concept of "coordination" for the first time [1]. Later German physicist H. Haken (1973) put forward the "synergy theory" based on the concept of "synergy". He proposed that coordination relies on the path of "Cause-Self Organizing Process-Phase change" to achieve coordination [2]. The synergy theory creatively puts forward the "entropy value" to measure the degree of system order. After that, Synergetic theory has been gradually deepened and expanded, and it applied to economics, sociology, management and other fields. Industrial synergy theory is an applied theory derived from synergy theory. When studying of the law of coordinated development of various industries, Michael. Porter (1983) believed that in the process of development there will inevitably be a trend toward synergy between different industries [3]. Based on the economic development of Europe in the last decade, Crisian. Antonelli (1998) explored the synergistic relationship between information technology industry and knowledge-intensive industry, he believed that the high and new technology industry can make the development of different industries gradually show a state of synergy. [4].

commerce and logistics are two typical industrial systems that can restrict and promote each other. Before 2014, most of the domestic literature focused on how logistics can support the development of e-commerce, or discussing the relationship between the two. And in the years that followed, domestic academic circles have gradually increased the research on the synergistic relationship between the two, especially the quantitative research on the degree of synergism. This is also directly related to the development of China's e-commerce and logistics industry. In the past ten years, both industries have achieved considerable development, and have formed a more obvious synergistic relationship. Han Juntao (2014) used CAS theory for multi-agent modeling and simulation to simulate and verify the interaction between e-commerce and logistics. And he verified the relationship of synergy and competition between the two groups by the Lotka-Volterra competition model, this relationship can promote the spiral development of logistics express delivery and e-commerce [5].

Lu Jingmin (2016) studied the e-commerce's logistics collaboration model of fresh agricultural products, two models of supply chain collaboration and multi-party business collaboration are obtained [6]. Wu Shuping (2016) and Liang Wen (2018) quantitatively studied the collaborative developing path of e-commerce and express delivery in China by using the system collaboration model [7][8].

To study the level of synergy degree between e-commerce and logistics industry in a certain region, and seek effective ways to promote the rapid development of the two, this has practical implications.

2. Development Status

According to the data of National Bureau of Statistics, In 2021, e-commerce sales in Jilin Province reached 58.71 billion yuan. It had increased of 11.66% over the same period last year, and the trend of sustained growth is obvious. By the end of 2021, the number of Internet users reached 7.342 million in Jilin Province, year-on-year growth was 12.2%. At the same time, the total length of highways increased from 94,200 km in 2013 to 10.87 km in 2021. It has laid a favorable foundation for the high-quality development of logistics industry in Jilin Province. In 2021, the total amount of logistics freight in Jilin Province was 535.87 million tons. The freight turnover was 20.686 million tons. The above data shows that, the two systems of e-commerce and logistics industry in Jilin Province have grown sustained and obviously in recent years.

Jilin Province selected Changchun Xinglong Comprehensive Free Trade Zone and Changchun New Area as the leading areas for cross-border e-commerce. They work together to form a dual dynamic cluster module of cross-border e-commerce industrial agglomeration area and cross-border e-commerce airport practice area. Jilin Provincial government has also given strong support to the development of logistics industry in the region. In 2012, the "Opinions on the Implementation of Policies and Measures to Promote the Healthy Development of the Logistics Industry" was issued. In "100 Policies and Measures for Expanding Opening-up in Jilin Province" released in 2019, the restrictions on the operation of the logistics and express delivery industry were widened. On the basis of the "Opinions of The General Office of the State Council on Promoting the Coordinated Development of E-commerce and Express Logistics" launched by the State in 2018 (State Office [2018] No. 1), In the same year, the "Notice of the General Office of the People's Government of Jilin Province on Issuing the Implementation Plan for Promoting E-commerce and Express Logistics Coordinated Development " was launched (No.22 [2018]). To sum up, in the process of promoting the development of the two industries, what Jilin Province lacks is the measurement of the coordinated development of the two systems and the countermeasures to promote the coupling development of the two industries.

3. Construction of Coupling synergy Degree Model

3.1. Research Method

The degree of coupling synergy is derived from the entropy method, It is used to reflect the degree of connection between two or more systems. Therefore, it can reflect the cooperative development of the system. The higher the index weight value in the system index system, the lower the information entropy value, the more information the data reflects, the more useful it is. On the contrary, as the entropy of information increases, the amount of information it contains is less, and the role it plays is also small. Finally, the information entropy value is used to calculate the comprehensive development index of the two systems to evaluate the coupling degree of cooperation between the systems.

① Data Standardization Processing

forward indicator: $x_{ij} = \frac{X_{ij} - X_{imin}}{X_{imax} - X_{imin}}$; negative indicator: $x_{ij} = \frac{X_{imax} - X_{ij}}{X_{imax} - X_{imin}}$

In the formula, x_{ij} is the value after normalization, X_{imax} is the maximum value corresponding to the j term indicator, and X_{imin} is the minimum value corresponding to the j term indicator.

② Indicator Non-negative

In order to ensure the integrity and credibility of the data, so as to ensure the scientificity and authenticity of the research, for data that is equal to zero after normalization, this paper reassigns a small positive value to the 0 value, and selects 0.001 as the translation quantity, which is included in the calculation process.

③ Weights of Indicators

Calculate the proportion of the indicator value of the i observation object under the j indicator.

$$w_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \left(0 \le w_{ij} \le 1\right) \tag{1}$$

④ Calculate the information entropy of the j indicator

$$e_j = -\frac{1}{\ln_m} \sum_{i=1}^{m} w_{ij} \mathrm{In} w_{ij} \tag{2}$$

⑤ Calculate the information utility value of the j indicator

The d value is the difference between 1 and the information entropy of that indicator, It has a direct effect on the weight size. The larger the d value, the more important it is to the evaluation object.

The calculation formula is:

$$d_j = 1 - e_j \tag{3}$$

⑥ Calculate the weight value of the indicator

Information utility value is used to determine the weight of indicator j:

$$c_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{4}$$

⑦ Calculate the comprehensive evaluation index of k system:

$$Q_k = \sum_{j=1}^{n} c_j x_{ij} \tag{5}$$

⑧ Calculate of coupling synergy degree:

The comprehensive evaluation indicator in formula (5) is used to calculate the coupling synergy degree between the two systems. The calculation formula is as follows:

$$T = \alpha * Q_1 + \beta * Q_2$$

$$C = \sqrt{Q_1 * Q_2} / (Q_1 + Q_2)$$

$$D = \sqrt{C * T} \tag{6}$$

Q_1 is the comprehensive development index of logistics system, Q_2 is the comprehensive development index of e-commerce system. α is the proportion of logistics subsystem in the whole composite system, β is the proportion of electronic commerce subsystem in the whole composite system. In view of the collaborative development of e-commerce and logistics, the two subsystems are interrelated and interact with each other, $\alpha = \beta = 0.5$ accordingly. It indicates that e-commerce subsystem and logistics subsystem play the same role in the process of collaborative development. The collaborative development system of e-commerce and logistics includes two subsystems: e-commerce and logistics. The Synergy degree C reflects the contribution of e-commerce and logistics industry to the Synergy degree. T represents the comprehensive coupling index of e-commerce subsystem and logistics subsystem, Its value range is [0,1]. When the value of T approaches 1, it indicates that the coupling degree of e-commerce subsystem and logistics subsystem is higher, and when the value of T approaches 0, it indicates that the coupling degree of the two systems is lower.

3.2. Determination of Coupling Synergy Degree

According to the calculation of C and D in formula (6), the coupling synergy between Q_1 and Q_2 of the two systems can be determined according to the numerical relationship between C and D. The coupling stage of e-commerce system and logistics system is divided into 6 stages. Coupling levels are divided into 10 levels. The specific criteria are shown in Table 1.

Table 1. Criteria for coupling development of the two systems

coupling degree	coupling phase	coupling synergy degree	synergy strength
0＜C≤0.3	low level coupling stage	0<D≤0.1	extreme disorder
		0.1<D≤0.2	severe disorder
0.3＜C≤0.5	Antagonistic state	0.2<D≤0.3	moderate disorder
		0.3<D≤0.4	mild disorder
0.5＜C≤0.8	Run-in stage	0.4<D≤0.5	Borderline disorder
		0.5<D≤0.6	Scarcely synergy
0.8＜C≤1	High level coupling stage	0.6<D≤0.7	Slightly synergy
		0.7<D≤0.8	Moderate synergy
C=1	Benign resonance coupling	0.8<D≤0.9	Well synergy
		0.9<D≤1	Quality synergy

3.3. Construction of index system

Logistics industry and e-commerce industry as two closely interactive and mutually promoting systems. At present, the academic community has not produced a unified index system that can effectively measure the coordinated development of the two. On the basis of previous studies by domestic and foreign scholars, this paper takes the level of logistics development, manpower input and infrastructure as the criterion level of logistics system. And express business income, freight volume, freight turnover, logistics employees and highway transportation mileage are selected as the index layer of the logistics system. In this paper, the three parts of e-commerce transaction level, Internet application level and e-commerce basic level are regarded as the criterion layer of e-commerce subsystem. And the total amount of e-commerce transactions, the scale of Internet users, the number of web pages, the proportion of e-commerce enterprises and the number of e-commerce enterprises are selected as the index layer of the e-commerce subsystem. The details are shown in Table 2 and Table 3:

Table 2. E-commerce System Evaluation Index System

target layer	criterion layer	index layer	symbol	unit	positive and negative attribute
E-commerce system	e-commerce transaction levels	total e-commerce transactions	X1	hundred million yuan	+
	Internet application level	size of Internet broadband users	X2	ten thousand households	+
		number of pages	X3	ten thousand	+
	basic level of e-commerce	the proportion of e-commerce enterprises	X4	%	+
		number of e-commerce enterprises	X5	one	+

Table 3. Evaluation Index System of Logistics Industry

target layer	criterion layer	index layer	symbol	unit	property
Logistics industry system	Logistics development level	express revenue	Y1	hundred million yuan	+
		volume of freight traffic	Y2	ten thousand tons	+
		freight turnover	Y3	100 million ton-kilometers	+
	manpower input level	number of logistics employees	Y4	thousands of people	+
	logistics infrastructure level	highway mileage	Y5	ten thousand kilometers	+

4. Empirical Analysis

4.1. Data Processing

According to China Statistical Yearbook, State Post Bureau and existing relevant website information, the data list of the development of e-commerce industry and logistics industry in Jilin Province from 2017 to 2021 is summarized. The specific values are shown in Table 4:

Table 4. Jilin Province e-commerce system and logistics industry system index data table

Electronic commerce system indicators	unit	2017	2018	2019	2020	2021
Total e-commerce transactions X_1	hundred million yuan	587.1	525.8	596.8	553.1	538.0
Size of Internet broadband users X_2	ten thousand households	734.2	654.2	618.3	588.2	501.5
Number of pages X_3	ten thousand	195089	189554	205285	180765	152994
The proportion of e-commerce enterprises X_4	%	5.6	5.5	5.1	4.9	4.3
Number of e-commerce enterprises X_5	one	673	595	537	635	717
Logistics industry system indicators	unit	2017	2018	2019	2020	2021
Express revenue Y_1	Hundred million yuan	30.45	37.71	48.33	60.73	76.92
Volume of freight traffic Y_2	ten thousand tons	49903	52516	43193	44848	53587
Freight turnover Y_3	100 million ton-kilometers	1634.6	1704.7	1802.7	1865.1	2068.6
Number of logistics employees Y_4	thousands of people	162482	148656	163199	164966	157794
Highway mileage Y_5	Ten thousand kilometers	103896	105399	106660	107848	108691

To process the data in Table 4 without dimension, and to calculate the weight w_{ij} of the indicator value of the i observation object under the J_{th} indicator according to formula (1) - (4), information entropy e_j, and the weight value of each indicator c_j. As shown in Table 5:

Table 5. Entropy and indicators weights of e-commerce and logistics systems

target layer	system layer	criterion layer	Indicator layer	entropy e_j	Indicator weight c_j
Electronic Commerce and Logistics system	Electronic Commerce subsystem	level of e-commerce transactions	total e-commerce transactions X_1	0.7492	0.1829
		Internet investment level	size of Internet broadband users X_2	0.7513	0.1813
			number of pages X_3	0.9368	0.0461
		Basic level of e-commerce	the proportion of e-commerce enterprises X_4	0.5081	0.3586
			number of e-commerce enterprises X_5	0.6830	0.2311
	Logistics subsystem	logistics development level	express revenue Y_1	0.7558	0.2327
			volume of freight traffic Y_2	0.7743	0.2150
			freight turnover Y_3	0.7558	0.2327
		manpower input level	number of logistics employees Y_4	0.8499	0.1429
		logistics infrastructure level	highway mileage Y_5	0.8146	0.1766

4.2. Coupling synergy degree judgment

The composite index Q_k was calculated according to formula (5), the comprehensive index of e-commerce Q_1 and logistics industry composite index Q_2 are obtained. According to the calculation formula of coupling synergy degree, the coupling degree C and coupling synergy degree D of e-commerce and logistics industry in Jilin Province from 2017 to 2021 are estimated. Based on this, the coupling and coordination stage of e-commerce and logistics industry in Jilin Province is judged every year. As shown in Table 6.

Table 6. Related index of collaborative development

Given year	Q_1	Q_2	coupling degree C	coupling stage	coupling synergy degree D	coupling synergy stage
2017	0.2610	0.9105	0.4161	uncoupling stage	0.4937	near imbalance
2018	0.3232	0.5578	0.4819	uncoupling stage	0.4607	near imbalance
2019	0.4097	0.5416	0.4952	uncoupling stage	0.4853	near imbalance
2020	0.5989	0.4547	0.4953	uncoupling stage	0.5108	proximity coordination
2021	0.9381	0.2635	0.4137	uncoupling stage	0.4986	near imbalance

It can be preliminarily seen from Table 6 that the coupling degree C of e-commerce and logistics industry in Jilin Province shows a trend of first rising and then declining. And it is stable between 0.4-0.5, the coupling stage in which it is located has been in the uncoupling stage. In 2021, the coupling degree is the lowest value in the past year, only 0.4137. This shows that the two subsystems of e-commerce and logistics industry in Jilin Province are not highly cooperative, and can not achieve complementary advantages. As can be seen from the D value of coupling synergy degree, the two systems is basically in a state of imbalance, and it only be improved in 2020. Since 2021, affected by

the epidemic, logistics has obviously failed to keep up with the demand of e-commerce, and even logistics breaks often occurred. The overall value of the coupling synergy degree D hovers between 0.4607 and 0.5108.

5. Conclusion

Based on "synergy theory" and "industry synergy theory", this paper constructs the coupling synergy degree model of e-commerce. According to the development of the two industries in Jilin Province during the five-year period from 2017 to 2021, the information entropy and coupling synergy degree of the two systems are calculated by using the evaluation index system and logistics industry. The results show that the value of coupling degree and coupling synergy degree has been hovering around 0.4-0.5, and the level of coupling synergy degree has been hovering in the uncoupling stage. This shows that in Jilin Province, the two industries need to increase their efforts in collaborative development, and strive to cultivate a good state of collaborative development. Only in this way can we reduce the mutual constraints on the development of the two, and form a synergy to promote each other. In our point of view, it is necessary to increase improvement efforts from the perspectives of e-commerce supply chain, rural e-commerce, cross-border e-commerce and e-commerce logistics services.

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