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Identification and Judgment of logistics industrial cluster life cycle stages

Xiaoye Zhou, Huan Sun, Hongxue Zhang
School of Management, Shenyang University of Technology, Liaoning, (CHINA)

ABSTRACT

Identifying the different stages of logistics industrial cluster means a lot to obtain competitive advantage during the evolution. However, there is no general and simple method to divide the life cycle stages of cluster. The researches on how to identify life cycle stages of a certain cluster is less too. Therefore, a multi-dimensional method is proposed to identify logistics industrial cluster life cycle. First, principal component analysis method is used to analyze the main indexes of logistics industrial cluster life cycle. Second, Location Quotient method is applied on measuring the agglomeration degree of regional logistics industrial cluster. Then, logistic model is used to determine the key points and life cycle stages of logistics industrial cluster. Finally, it takes Shenyang Economic Zone as an example to identify life cycle stages of logistics industrial cluster. The result shows that pure aggregation stage of Shenyang Economic Zone logistics industrial cluster is from the year 2007 to June 2009. The netting stage begins from June 2009 to June 2017, and the innovation stage is from March 2017 to April 2028. It makes contributions to the sustainable development of logistics industrial cluster of Shenyang Economic Zone.

KEYWORDS

Logistic industrial cluster; Life cycle; Identification and judgment; Shenyang economic zone.

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INTRODUCTION

Tichy.G firstly proposed the cluster life cycle theory and divided the development and evolution of cluster into four stages: birth stage, growth stage, maturity stage and decline stage[1]. Then, life cycle theory arouses widespread concentration and discussion in academic circles. In addition to the division of cluster life cycle stages, more and more studies have focused on the characteristics of cluster life cycle stages. However, in practical applications, a general and simple method on how to divide cluster life cycle stages has not formed. And the researches on how to identify life cycle stages of a certain cluster are less too. Just like products and enterprises, logistics industrial cluster exists life cycle phenomenon[2]. With the evolution of cluster life cycle, the competitive advantage of logistics industrial cluster changed. Each stage of logistics industrial cluster must be identified to establish reasonable and effective policies to promote competitiveness during the evolution[3]. Therefore, a multi-dimensional method of identifying logistics industrial cluster life cycle is proposed to judge each stage of logistics industrial cluster.

THE MULTI-DIMENSIONAL METHOD TO IDENTIFY LOGISTICS INDUSTRIAL CLUSTER LIFE CYCLE STAGE

The principal component analysis

Principal component analysis (PCA) can reassemble original indexes into a new set of comprehensive indexes and reflect the original information as much as possible according to actual need[4]. Steps are as follows:

(1) Creating original data matrix standardization;
(2) Calculating the correlation coefficient matrix of original indexes;
(3) Computing the eigenvalue and eigenvector of correlation coefficient matrix;
(4) Determining the number of principal components;
(5) Calculating the total score.

The location quotient

In this paper, location Quotient (LQ) is used to measure the agglomeration degree of regional logistics industrial cluster. This method is widely used because it has the advantages of simple operation and convenient calculation[5]. And it can also reflect the main regional industry characteristics and agglomeration degree.

(1) According to the characteristics of the export-oriented, the logistics industrial agglomeration coefficient of a certain area can be reflected by input/output difference relations between regional logistics industry and external region.

$$LQ_i = \frac{e_i / e}{E_i / E} \quad (1)$$

(2) According to the characteristics of professional, the regional logistics industrial agglomeration degree can be measured by the absolute value of the difference between regional logistics industry employment proportions.

$$LQ_j = \frac{e_j / e}{E_j / E} \quad (2)$$

The construction of logistic model

Logistic model is one of the core theories of population ecology and it is almost the only mathematical model of describing the S-type growth of population[6]. The variation of enterprise number in logistics industrial cluster is similar to the population number. There is no clear boundary of cluster enterprises in the region. The total number of individuals is continuously changing over the time in the cluster. Therefore, establishing the logistic continuous model based on the enterprises number:

$$\frac{dN}{dt} = r \bullet N(\frac{K-N}{K}) = rN(1-\frac{N}{K}) \tag{3}$$

Get formula (3) deformed and obtain:

$$(\frac{1}{N} + \frac{1}{K-N})dN = rdt \tag{4}$$

Make integral transformation on both sides and obtain:

$$\frac{N}{K-N} = e^{rt+c} \tag{5}$$

N_o means initial density, when t=0, N_t=N_o, then

$$N_t = \frac{Ke^{rt+c}}{1+e^{rt+c}} \tag{6}$$

Then the right numerator and denominator are divided by e^{rt+c} and get:

$$N_t = \frac{K}{1+e^{-c}e^{-rt}} \tag{7}$$

In order to facilitate the research, make $e^{-c} = a$, r = b , then formula (4) can be expressed as:

$$N_t = \frac{K}{1+ae^{-bt}} \tag{8}$$

Calculating the first derivative of $N_t = \frac{K}{1+ae^{-bt}}$ can get the velocity function of single peak curve:

$$v(t) = \frac{dN}{dt} = \frac{Kabe^{-bt}}{(1+ae^{-bt})^2} \tag{9}$$

As shown in figure 1, the growth process of enterprises number is slow - fast - slow.

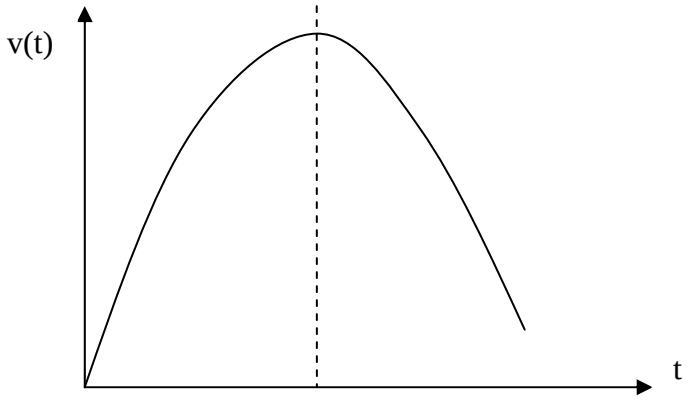

Figure 1 : Speed curve of logistic growth process

Calculate the first derivative of formula (9) and make it equals to zero. Then get:

$$\mathbf{t = \frac{\ln a}{b}} \tag{10}$$

So when $t = \frac{\ln a}{b}$, logistics industrial cluster is in the stage of the peak and the growth rate of enterprises number is the fastest. Calculating the second derivative of the growth rate of enterprises number and making it equal to zero:

$$\mathbf{\frac{d^2N}{dt^2} = \frac{Kab^3e^{-bt}(1-4abe^{bt}+a^2e^{-2bt})}{(1+ae^{-bt})^4} = 0} \tag{11}$$

$$\mathbf{t_1 = \frac{\ln a - 1.317}{b},\ t_2 = \frac{\ln a + 1.317}{b}} \tag{12}$$

t_1 and t_2 are the two inflection points on velocity function. t_1, t_2 and t are the three key points of logistic curve. The three key points divide the development process of the logistics industrial cluster into four stages: pure agglomeration stage, netting stage, innovation stage and decline stage, thus judging the life cycle stages of logistics industrial cluster and determining the starting point of each stage[7].

EXAMPLE APPLICATIONS

Index system of logistics industrial cluster life cycle stage identification

According to the selection principles of integrity and comparability, this paper creates evaluation index system that can reflect regional logistics industrial cluster life cycle characteristics from different angles[8]. The index system is shown in figure 2.

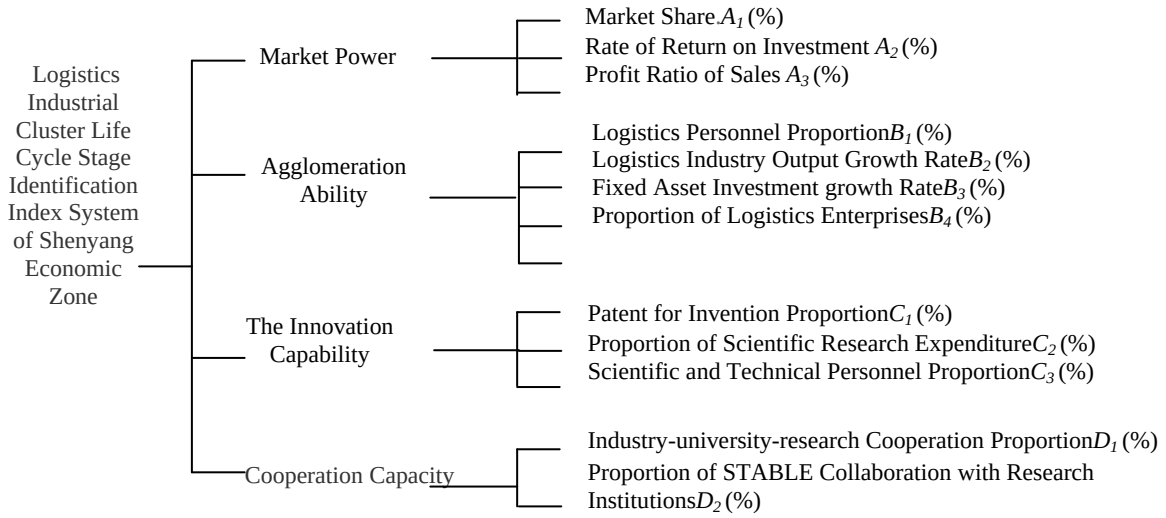

Figure 2 : Logistics industrial cluster life cycle stage identification index system of Shenyang economic zone

The indexes analysis of the logistics industrial cluster life cycle stages identification

According to the index system in Figure 2, this paper selects the data from the 2011 statistical yearbook of national and Liaoning province. The data of mean value and standard deviation is calculated in TABLE 1.

TABLE 1 : The data of indexes and the mean value and standard deviation

Index	A1	A2	A3	B1	B2	B3	B4	C1	C2	C3	D1	D2
2007	13.14%	7.21%	3.61%	22.67%	14.99%	14.99%	46.35%	3.98%	11.69%	10.28%	11.14%	2.91%
2008	15.87%	11.34%	7.24%	29.36%	15.18%	24.16%	52.53%	5.26%	14.38%	14.37%	16.31%	3.53%
2009	21.33%	16.82%	9.28%	33.27%	23.04%	26.72%	60.11%	6.79%	15.22%	18.51%	18.74%	4.79%
2010	26.10%	21.58%	11.57%	40.93%	29.87%	30.66%	65.21%	8.29%	17.43%	20.15%	21.34%	5.74%
The mean value	19.11%	14.24%	7.93%	31.56%	20.77%	25.52%	56.05%	6.08%	14.68%	15.83%	16.88%	4.24%
standard deviation	5.77	6.28	3.38	7.63	7.13	4.26	8.30	1.87	2.37	4.23	4.34	1.27

This paper uses software SPSS17.0 to analyze the principal component of the standardized data and calculate the eigenvalues. The contribution rate and accumulative contribution rate are shown in TABLE 2.

TABLE 2 : Total variance explained

Ingredient	Initial Eigenvalue			Extraction of Quadratic Sum		
	Total	Variance Percent %	Accumulative percent%	Total	Variance Percent%	Accumulative percent %
1	11.658	97.152	97.152	11.658	97.152	97.152

As shown in TABLE 2, choosing the first component as principal component is enough because its accumulative contribution rate is 97.152% which is more than 85%. Therefore, a new variable can be used to instead the original twelve variables. Multiplying the resulting eigenvalue and the standardized data can get the formula of the principal component. The final ranking is shown in TABLE 3.

TABLE 3 : Sample score and ranking

Factor Index	A1	A2	A3	B1	B2	B3	B4	C1	C2	C3	D1	D2
Ingredient 1	.989	.998	.993	.993	.944	.966	.998	.998	.985	.987	.985	.990
First principle component Y1	0854	.0859	.0852	.0860	.0810	.0830	.0862	.0859	.0840	.0852	.0850	.0847
Ranking	5	3	6	2	12	11	1	3	10	6	8	9

It can be seen from TABLE 3 that the proportions of logistics enterprises and logistics personnel of Shenyang economic zone are ranking on the top. As a result, this paper chooses the number of logistics enterprises and logistics personnel as two main indexes to judge logistics industrial cluster life cycle stages of Shenyang economic zone.

Measuring the agglomeration degree of shenyang economic zone logistics industrial cluster

Calculation results of the following indexes are shown in TABLE 4 and TABLE 5, according to the Liaoning statistics yearbook 2010 and Chinese statistics yearbook 2010.

TABLE 4 : LQi of Shenyang economic zone (One hundred million yuan)

Year Numerical program	2005	2006	2007	2008	2009
Shenyang economic zone logistics industry output value	318.2	346.4	419.1	482.7	593.9
Shenyang economic zone gross regional production	3900.54	4950.85	7098.43	7935.36	9694.91
National logistics industry output value	11143.3	13090.4	14963.5	17157.3	19894.2
Gross domestic product (GDP)	183217.4	211923.5	257305.6	300670.0	335353.0
LQi	1.341307	1.132725	1.015246	1.065987	1.032631

TABLE 5 : LQj of Shenyang economic zone (million)

Year Numerical program	2005	2006	2007	2008	2009
Shenyang economic zone logistics industry staff number	15	16	16	17	17
Shenyang economic zone all industry staff	1312	1375	1428	1449	1467
The national logistics industry staff number	614	613	623	627	631
The national staff number of all industry	75825	76400	76990	77480	77995
LQj	1.4119	1.4503	1.3846	1.4498	1.4324

The result shows that the location quotient coefficient of Shenyang Economic Zone logistics industrial cluster is greater than 1. So the logistics industrial cluster agglomeration degree and logistics personnel number of Shenyang Economic Zone is higher than the national average.

TABLE 6 : The comparison of agglomeration degree

Agglomeration degree index	Shenyang economic zone	Changzhutan city group	Binhai New Area of Tianjin	Wuhan Urban Agglomeration
LQi	1.03263	0.98583	0.96505	0.81516
LQj	1.43240	0.80659	0.87105	0.82453

As shown in TABLE 6, the LQ of Shenyang Economic Zone logistics industrial cluster is greater than l, while the LQ of other economic zones are about 0.8 which is worse than Shenyang Economic zone. Although LQ_j represents the LQ of logistics personnel, it is still able to explain that the logistics industrial cluster agglomeration degree of Shenyang Economic Zone has competitive advantage compared with other economic zones. Therefore, judging life cycle stages of Shenyang Economic Zone logistics industrial cluster on this basis is very necessary.

Constructing logistic model and solving parameters

After collecting the data of logistics enterprises proportion in Shenyang Economic Zone logistics industrial cluster from 2007 to 2010, this paper makes non-linear regression analysis to get the value of K by SPSS software.

TABLE 7 : The proportion of logistics enterprises settle in Shenyang Economic Zone

Year: t	2007	2008	2009	2010
The proportion of logistics enterprises :Y	46.35%	52.53%	60.11%	65.21%

The scatter diagram is shown in Figure 3.

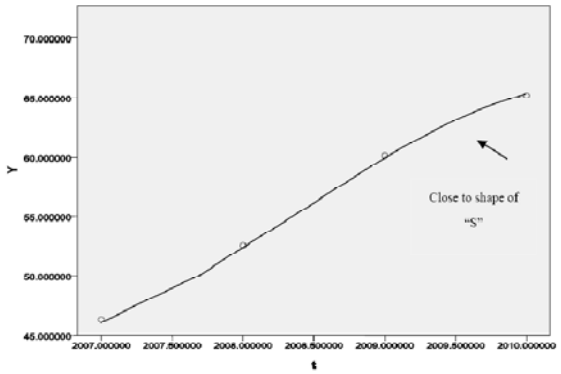

Figure 3 : The scatter diagram of logistics enterprises proportion with the year change

It can be seen from Figure3 that the change of logistics enterprises proportion is a non-linear process that approximates to logistic curve. Using the data in TABLE 7 to calculate K can get K = 75.05, a = 8.97, b = 0.35. The goodness-of-fit coefficient R^2 is 0.996, which means that the result fits very well. So Shenyang Economic Zone logistics industrial cluster logistic prediction model can be expressed as follows:

$$N_{(t)} = \frac{75.05}{1 + 8.97e^{-0.35*t}}, \quad t>0 \qquad (13)$$

The life cycle curve of shenyang economic zone logistics industrial cluster

Based on the year of 2007, this paper builds logistics industrial cluster development stage identification model of Shenyang Economic Zone and simulates the dynamic development of system. Taking logistics enterprises proportion as the only index, it draws the logistics industrial cluster life cycle curve of Shenyang Economic Zone, which is shown in Figure 4.

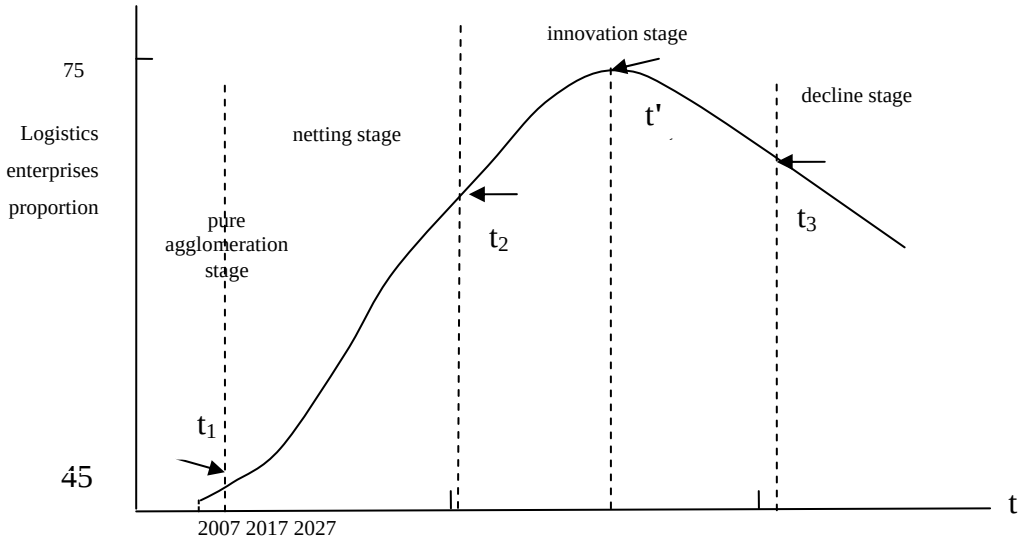

Figure 4 : The life cycle curve of Shenyang Economic Zone logistics industrial cluster

RESULT ANALYSIS

The first special point of the curve is $t_1 = \frac{\ln a - 1.317}{b} = 2.505$, which indicates that the pure aggregation stage of Shenyang Economic Zone logistics industrial cluster is from the year 2007 to June 2009. In this phase, the number of logistics enterprises and logistics personnel is small, but the growth rate is fast. The second special point of the curve is $t_2 = \frac{\ln a + 1.317}{b} = 10.03$, which indicates that the netting stage of the cluster begins from June 2009 and ends up at June 2017. At present, Shenyang Economic Zone logistics industrial cluster is at the netting stage. The cluster has expanded rapidly. A large number of enterprises have entered the cluster and the personnel number has increased significantly. But when the cluster comes to the year of 2017, the growth rate of enterprises and personnel number will slow down gradually and get to the peak of the curve. Then the cluster will get into innovation stage. The third special point of the curve is $t_3 = 21.16$, which indicates that the innovation stage of the cluster is from March 2017 to April 2028. At this stage, Shenyang Economic Zone logistics industrial cluster is in steady state. It will enter decline stage in April 2028.

CONCLUSIONS

Logistics industrial cluster is attracting more and more attention because of its effective way of improving the enterprise production efficiency and regional economic competitiveness. This paper mainly focuses on the method of identifying logistics industrial cluster life cycle stage on the foundation of life cycle theory. It takes Shenyang Economic Zone as an example to build the logistics industrial cluster life cycle identification index system. Then it identifies the logistics industry cluster life cycle stages from a multi-dimensional perspective. This method can determine the development stages of logistics industrial cluster and key points timely and accurately, which provides an effective theoretical guidance for the development and upgrading of regional logistics industrial cluster. The result analysis of Shenyang Economic Zone will also make contributions to the sustainable development of logistics industrial cluster.

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