Calculation and Analysis of the Synergetic Degree Model between Modern Logistics and Transportation Industry in Gansu Province

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Abstract

In this paper, it fully illustrated the spirit of collaboration, theory and methodology which based on an integrated approach to research econometric model by using synergetic degree, which combines the coordinated development between transportation and logistics industry in Gansu Province, and builds evaluation index system to study the degree of synergy of development in Gansu Province. It is practical significance to transportation and development of modern logistics industry in Gansu Province.

Keywords : *synergetic degree , model , influence factor analysis.*

1. Introduction

It has formed a certain scale industry which developed foreign transportation system, extensive road network in all directions, and with the privilege of modern logistics development. Foreign countries have a profound understanding of the collaborative relationship between the development of transportation and logistics. The transportation lag would seriously hamper the development and progress of the logistics; And with the rapid development of the logistics and lack of investment in transportation; It seems like it would be even more important for effective combination of these two. Therefore, the United States, the United Kingdom and other countries stands at a strategic point, they integrated and specialized transportation and modern logistics, and gradually achieved a balanced stage to unify collaborative development and mutual promotion between the two.

Due to various factors, such as economic development and social progress, China's transportation and logistics industry is still in a developing state, the domestic literature about these two studies can be roughly divided into three categories: (1) transportation and modern logistics interaction ([1], [2]); (2) the development of the transportation and modern logistics ([3], [4]); (3) the function of economy in development of modern logistics or transportation ([5], [6]).

2. Measurement Model of Synergetic Degree

2.1 Synergetic Degree

Synergetic degree is reacting the coordination degree between systems, so this paper uses synergetic degree to study of the development between transportation industry and modern logistic. Hypothesis F(X) represents the comprehensive development index of transportation system, X is the set of transportation system index , $X=(X_1,X_2,X_3 \cdots \cdots X_n)$. F(Y) represents comprehensive development index of modern logistics system, Y is the set of modern logistic system index, $Y=(Y_1,Y_2,Y_3\cdots\cdots Y_n)$.
According to the analysis of the synergetic degree, the deviation between system is smaller, the synergetic degree between system is better, the deviation of the expression is:

$$C_V = \frac{|F(X)-F(Y)|}{\frac{1}{2}[F(X)-F(Y)]} = \sqrt{\frac{[F(X)-F(Y)]^2}{[\frac{F(X)-F(Y)}{2}]^2}} = \sqrt{1-\frac{F(X)\bullet F(Y)}{[\frac{F(X)+F(Y)}{2}]^2}} \quad (1)$$

Because of C_V is the smaller the better, so rolled out , $\frac{F(X)\bullet F(Y)}{[\frac{F(X)+F(Y)}{2}]^2}$ is the bigger the better, Therefore, define synergetic degree C expressions for:

$$C=\left\{\frac{F(X)\bullet F(Y)}{\left[\frac{F(X)+F(Y)}{2}\right]^2}\right\}^K \quad (2)$$

(K is the adjustment coefficient, K equals to two)

The range of C to [0, 1], the value of C reflects the degree of coordination between the systems, and the value of C is bigger , the development of the relationship between system is more coordination; the value of C is smaller, it means the development of the relationship between system is not harmonious. In two systems, the development level under certain situation, if you want to make the relationship of system more coordination, it is necessary to make F(X)•F(Y) of the largest value, from the view of mathematics, when F(X)=F(Y), the value of F(X)•F(Y) is largest, the development between systems is the most harmonious, namely C equals one. But in reality, the development between systems is impossible to achieve fully coordinate, so pursuits of the value of C the bigger the better.

2.2 Static Synergic Degree and Dynamic Synergic Degree

Synergic degree is divided into two kinds: static synergic degree and dynamic synergic degree. Static synergic degree reaction collaborative development between systems at a given moment. Dynamic coordination degree is based on the static state, reaction the coordination development trend of systems with the passage of time.

（1）Static Synergic Degree

Through calculating of static synergic degree in different time point to reacting the coordinated development between systems. D_S is the static synergic degree, the calculation formula for :

$$D_S=\sqrt{C\bullet T},\ T=\alpha F(X)+\beta F(Y) \quad (3)$$

Among them, the range of D_S to [0,1], α , β are the coefficients of comprehensive development index, α equals to 0.4, β equals to 0.6.The value of D_S is bigger, the development synergic effect between systems is better; on the other hand, the development synergic effect between systems is worse, namely:

$$\begin{cases}0<D_s\le 0.4, \text{Primary stage of coordinated development}\\ 0.4<D_s\le 0.7, \text{Intermediate stage of coordinated development}\\ 0.7<D_s\le 1, \text{Advanced stage of coordinated development}\end{cases} \quad (4)$$

（2）Dynamic Synergic Degree

Static coordination degree is limited in a moment, in order to eliminate the influence of time, using dynamic coordination degree to reaction the coordination development trend of systems with the passage of time. With $D_S(t)$ and $D_S(t-1)$ respectively represents the coordinated development degree of t and t-1 moment, D_d is for dynamic synergic degree, the calculation formula for

$$D_d=\frac{D_s(t)}{D_s(t-1)} \quad (5)$$

Among them ,$D_S(t)$ is the coordination degree of t time, $D_S(t-1)$ is the coordination degree of t-1 time. When $D_d>1$, system is in the growth state of coordinated development; $D_d=1$, the coordinated development of system maintains the original state; $D_d<1$, system is in the lower state of coordinated development.

3. Synergic Degree and Correlation Analysis between Its Influencing Factors

Through the calculation of coordination degree, when the development between systems present disharmony, in order to realize the coordinated development between the systems, it is necessary to adjust the system, and the system is composed by many factors, so need to through the correlation analysis between influence factors and synergic degree, deciding which factor should be adjusted. If the influencing factors and the degree of coordination is positively related, then it should be actively development of the element; if it is negative correlation relationship, it should be inhibit the development of the elements.

x_1, x_2, $x_3\cdots\cdots x_n$ are the influence factors of coordination degree in transportation and modern logistics industry, the correlation matrix for synergic degree and its Influencing

factors is : $R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}$,

Among them,

$$r_{ij} = \frac{\sum_{k=1}^{n}(x_i(k)-\bar{x}_i)(x_j(k)-\bar{x}_j)}{\sqrt{\sum_{k=1}^{n}(x_i(k)-\bar{x}_i)^2 \sum_{k=1}^{n}(x_j(k)-\bar{x}_j)^2}}, \bar{x}_i = \frac{1}{n}\sum_{k=1}^{n} x_i(k)$$

In the formula, r_{ij} is the correlation coefficient between factors i and j, so r_{ij} is the correlation coefficients of transportation industry and modern logistics industry between synergic degree and its influencing factors, when r_{ij} is close to 1 or -1, illustrate the relationship between x_i and x_j is very strong; when r_{ij} is close to 0, shows the correlation between x_i and x_j is very weak. Thus can judge the influence factors on the synergic degree, which can provide the decision-making to collaborative development between system.

4. Synergic Degree Calculation of Transportation Industry and Modern Logistics Industry in Gansu Province

4.1 The Establishment of Evaluation Index System and The Original Data Collection

Table 1 : the framework and data of transportation system index

index / year	Railway operation miles (kilometers)	highway operation miles (kilometers)	amount of railway truck (million)	ownership of highway truck (ten thousand units)	network density of railway transport (km/square kilometers)
2001	1887	38976	7.81	6.64	41.56
2002	1910	39354	7.92	6.89	42.07
2003	1923	40659	8.05	7.32	42.36
2004	1987	40751	8.23	43.76	43.76
2005	2013	41300	8.67	8.33	44.34
2006	2231	46108	9.64	9.14	49.14
2007	2464	59873	9.72	54.27	54.27
2008	2466	70735	9.8	10.38	54.32
2009	2468	114000	9.78	12.24	54.36
2010	3093	119000	9.88	14.06	68.13

index / year	network density of highway transport(km/square kilometers)	network saturation	basic construction investment of transportation(one hundred million)
2001	858.50	1.229	124.2
2002	866.82	1.205	128.4
2003	895.57	1.215	135.3
2004	897.59	1.213	139.1
2005	909.69	1.257	143.7
2006	1015.59	1.231	165.6
2007	1318.79	1.311	150.8
2008	1558.04	1.242	179.9
2009	2533.33	1.235	293. 3
2010	2621.14	1.221	482.8

Table 2 : the framework and data of modern logistic system

index / year	GDP (one hundred million)	Population (million)	Social total retail sales of consumer goods (one hundred million
2001	1073	2575.24	395.43
2002	1161	2592.58	433.54
2003	1301.06	2603.34	474.6
2004	1558.93	2618.78	535.84
2005	1928.14	2594.36	632.8
2006	2275	2606.25	717.47
2007	2699.2	2617.16	833.32
2008	3176.11	2628.12	990.14
2009	3382.35	2635.46	1183.01
2010	4119.46	2557.53	1369.4

index / year	Railway freight turnover (ton-km)	Highway freight turnover (ton-km)	Waterway freight turnover (ton-km)
2001	458.91	114.02	0.06
2002	472.21	118.54	0.06
2003	508.94	123.85	0.07
2004	616.06	130.01	0.07
2005	717.56	137.31	0.07
2006	776.84	146.59	0.07
2007	868.06	156.48	0.08
2008	979.58	169.04	0.08
2009	987.13	489.72	0.08
2010	1082.98	524.09	0.08

Continued from Table 2

index / year	Air freight turnover (ton-km)	Total investment of the whole society(one hundred million)	Added value of logistics industry (one hundred million)	added value of industrial		
				The first industry (one hundred million)	The second industry (one hundred million)	The third industry (one hundred million)
2001	0.16	133.97	134.76	207	481	385
2002	0.17	127.21	137.56	214	530	417
2003	0.21	118.65	145.23	240	607.62	453.44
2004	0.19	109.04	156.12	281.4	758.18	519.35
2005	0.15	131.16	167.31	300	836.55	791.59
2006	0.16	135.7	178.54	333.23	1048.19	893.58
2007	0.19	114.85	184.22	386.42	1282.22	1030.56
2008	0.21	105.82	211.11	462.27	1471.43	1242.41
2009	0.21	145.04	213.64	497.50	1510.98	1373.87
2010	0.18	187.35	227.18	599	1984.97	1535.49

According to the above index data and principal components analysis method, concluded the comprehensive development index value of transportation and modern logistics system in Gansu province shown in table 3, 4:

Table 3 : comprehensive development index of transportation system

Year	F(X)
2001	-0.791
2002	-0.851
2003	-0.738
2004	-0.638
2005	-0.311
2006	-0.030
2007	0.620
2008	0.435
2009	0.843
2010	1.460

Table 4 : comprehensive development index of modern logistics system

Year	F(X)
2001	-1.049
2002	-0.892
2003	-0.459
2004	-0.309
2005	-0.381
2006	-0.127
2007	0.394
2008	0.831
2009	1.041
2010	0.954

Among them, F(X) is comprehensive development index of system.

4.2 Calculation of Synergetic Degree

Comprehensive development index of transportation and modern logistic system has both positive and negative, according to the needs of the model of synergic degree, the tables 4-3 and 4-4 will be normalized, in order to make the result is positive, using minimum and maximum value method for normalization processing, multiplied by the corresponding coefficient, obtained comprehensive development index such as table 5 and 6 shows.

Table 5: transportation system

Year	F(X)
2001	0.1235
2002	0.1
2003	0.143
2004	0.1830
2005	0.3103
2006	0.4195
2007	0.6727
2008	0.6010
2009	0.7598
2010	1

Table 6: comprehensive development index of modern logistic system

Year	F(X)
2001	0.1
2002	0.1674
2003	0.3537
2004	0.4182
2005	0.3873
2006	0.4968
2007	0.7212
2008	0.9092
2009	1
2010	0.9624

From the formula (1)~(4) calculating the synergic degree of transportation system and modern logistics system, the calculation results are shown in table 7:

Table: 7 :synergic degree of transportation and modern logistic system

Year	D_S	D_d
2001	0.3271	1.0621
2002	0.3509	1.0729
2003	0.4272	1.2172
2004	0.4823	1.1290
2005	0.5898	1.2229
2006	0.6777	1.1490
2007	0.8367	1.2346
2008	0.8496	1.0154
2009	0.9330	1.0981
2010	0.9869	1.0577

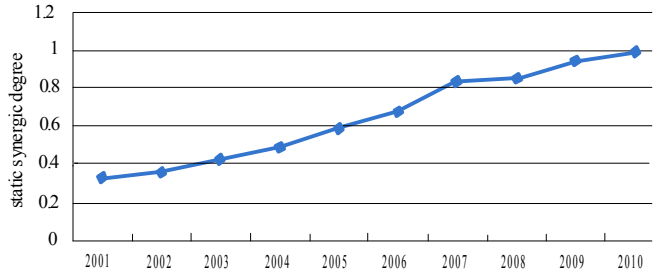

Fig.1: synergic degree of transportation and modern logistic industry in Gansu Province

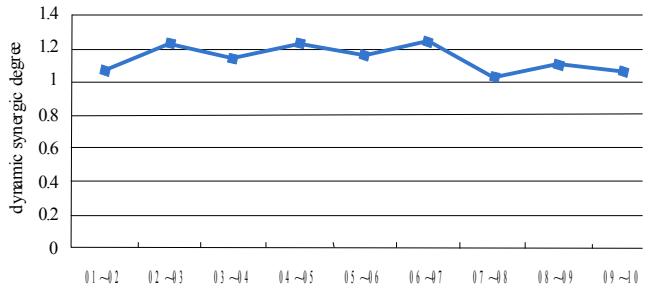

Fig. 2: development trend of transportation and modern logistic system in Gansu Province

Analysis of Fig.1 and 2 can be concluded by:

(1) Coordinated development of transportation and modern logistics industry in Gansu Province, the initial development to the collaborative development from 2001 to 2010, the advanced stage of synergetic degrees increased annually. This means, with the economic development of Gansu Province and people's living standards, it has put forward higher requirements to the transportation and modern logistics industry. By coordinating and cooperating of these two, it not only completes their own development, but also promotes each other's development. Thus, it contributes to the Gansu Provincial with integrated development of the transportation industry and modern logistics industry.

(2)The dynamic synergic degree of transportation and modern logistic in Gansu Province is greater than one, that the system is in the growth state of coordinated development, but the growth range is different, which may be related to the government's macro-control and the speed of economic development.
Although, coordination development of transportation and modern logistic industry is better, but in order to improve the development between them, still need to analyze the relevance between synergic degree and its influence factors.

5. Analysis the Influence Factors of Synergic Degree of Transportation and Logistic in Gansu Province

There are a lot of factors to influenced transportation industry and modern logistics industry as well as the synergic degree between them in Gansu Province. In this paper, choosing two representative, able to quantitative indicators in two systems, performing correlation analysis with synergic degree.

In the transportation system, choosing railway operation miles(X1), highway operation miles(X2), amount of railway truck(X3), basic construction investment of transportation(X4); in the modern logistic system, choosing GDP(X5), social total retail sales of consumer goods(X6), railway freight turnover(X7), highway freight turnover(X8), air freight turnover(X9), analysis the relationship between these nine indexes and synergic degree.

Under the guidance of Pearson correlation analysis theory, with the help of SPSS software, computing the correlation coefficient between the nine factors and synergic degree. The results as shown in table 7.

Table 7: correlation coefficient between the nine factors and synergic degree

Factors	Correlation coefficient
X1	0.891
X2	0.816
X3	0.921
X4	0.690
X5	0.964
X6	0.938
X7	0.989
X8	0.713
X9	0.331

According to the size of the correlation coefficient in order: X7> X5> X6 > X3 > X1> X2> X8> X4> X9, From the size of the coefficient can be seen, the transportation and modern logistic industry in Gansu Province affected by railway transportation is bigger, because of Gansu Province is the hub of Northwest Railway. Secondly, economic indicators, such as GDP, social total retail sales of consumer goods affect their synergic degree is also bigger, synergic degree affected by aviation is lowest among the chosen indicators.

6. Conclusion

This paper takes Gansu Province as the object, introducing the concepts and methods of synergetic, from the perspective of coordinated development to research integrated development between transportation and modern logistic industry in Gansu Province, and establishment the comprehensive evaluation index system, using principal component analysis methods to process the index, based on it to establish the computing model of synergic degree, calculating the synergic degree between them, and analyze the correlation between the synergic degree and its influence factors. Finally, combined with the actual development of Gansu province, verify that the validity of index and practicability of the design method.

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