The Correlation Analysis of Chongqing Transportation Structure and Industrial Structure

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Abstract. National economy is closely related to the transportation structure, and the adjustment of industrial structure influences and changes the development of transportation structure. Taking Chongqing as an example, we observe the development status of industrial structure and the transport industry with qualitative analysis. Combined with gray relational theory, we can describe and analyze the detailed relationship between industrial structure and transport structure quantitatively. And the correlation degree would allow us to represent the competing models among the three main transportation modes, thus providing a theoretical basis for a reasonable forecast of transport development.

Keywords: Industrial structure, Transportation structure, Grey correlation degree.

1. Introduction

Transportation structure reflects the development and scope of the regional transportation, and simultaneously national economy is one of the important factors affecting the regional transport structure. The changes and adjustment in the industrial structure of the national economy will derive different transport needs, and in turn require transportation structure to make the appropriate improvement. In recent years, Chongqing has gained rapid economic and social development. In 2013 the city's GDP reached up to 1.265669 trillion yuan, with an increase speed of 12.3%. Among them primary industry output is 100.268 billion, secondary industry 639.792 billion, and the tertiary industry value 525.609 billion. The proportion of three industries production value changes from $8.2 : 52.4 : 39.4$ to $7.9 : 50.5 : 41.6$. National economy is closely related to the transportation structure, the development of economy would inevitably bring the change the development of transportation structure. Li Dawei etc. analyzed how different factors influence the transportation structure, and mainly describe the evolution of transportation structure from the qualitative point of view [1]. Peng Xiangtao discusses the relationship between transportation and industrial structure adjustment through qualitative analysis, and points out that transportation is the foundation of national economic development. And the influences changes according to economy and society [2]. Li Chongliang explores the impact of industrial structure changes theoretically using correlation analysis method and gray relational analysis theory. Furthermore takes empirical analysis in Xining City for both qualitative and quantitative research [3]. Nie Zhengying builds the complete decomposition model to analyze and predict the influences that industrial structure yield to transportation structure [4]. Chu Kebo preliminarily analyzes the correlation relationship between the development of Sichuan passenger and freight transport and industrial structure changes from gray system association mode [5]. Feng Xunjie etc use the co-integration theory to study the long-term equilibrium relationship between passenger and freight traffic and the three industries [6]. Wu Feng analyzes such relationship by examining the entropy causality of industrial structure and transportation structure [7]. In this paper, we will begin with the current situation of Chongqing industrial structure, combined with structural changes of transportation in recent years, and then use gray correlation theory to quantify the influences in order to provide theoretical support for the Chongqing transportation future development strategy.

2.   The Scale and Change of Chongqing Industrial Structure

2.1 The growth of Chongqing GDP

Chongqing has gained a rapid economic development in recent years, and GDP shows a steady upward trend, increases from 160.238 billion yuan in 1998 to 1.265639 trillion yuan in 2013, with an average annual growth rate of 15.91 percent and an average annual growth value of about 73.7 billion yuan. These data show and reflect the high growth of Chongqing society and economy; simultaneously such growths will effectively stimulate and promote the development of transportation in this region.

2.2 The adjustment of Chongqing industrial structure

As shown in Figure1, the three major industries developed fast in Chongqing, while the secondary and tertiary industries faster. In detail, the growth of secondary industry is slowing down, and the tertiary industry catches up. The hiding reason is the government policies which encourage to upgrade industrial structure and transform economic growth mode. In the composition of 2013 Chongqing GDP, the primary industry accounted for 7.9%, secondary and tertiary industries were 50.5% and 41.6%.
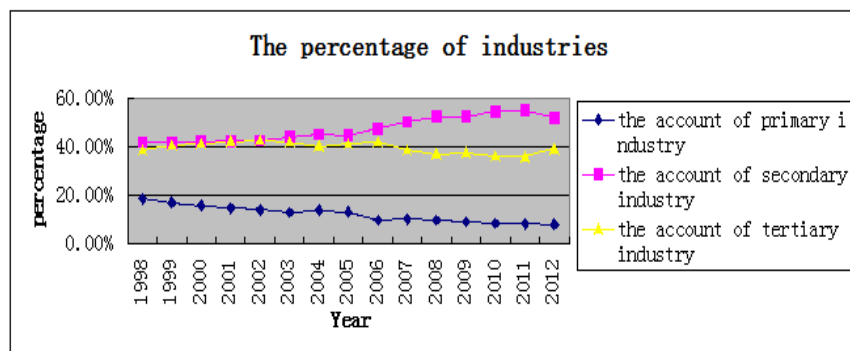

Figure 1 the percentage of three industries in Chongqing

3.   The Development of Chongqing Transportation

3.1 The changes of the total transportation traffic

After a review of the historical data we can find an overall increasing trend in passenger and freight traffic, and the cargo turnover stands out. Meanwhile, through observation we find that the growth rate has accelerated since 2000. The whole passenger traffic and passenger turnover were 1577 million and 75.5 billion person/km in 2012, about three times of the passenger traffic and passenger turnover in 1998. The average annual growth rate reached up to 8.7%. What's more, the freight traffic and turnover attained 1101.36 million tons and 283.1 billion tons-kilometers, approximately 4.35 times and 10.55 times of 1998, and the average annual growth rates were even higher, reached up to 11.06% and 18.32%.

In terms of passenger traffic (Figure 2), the traffic of road transport and aviation have maintained a rapid growth. The railway traffic and turnover showed an overall upward trend except the declination in 2005 for the railway segment redevised. The aviation passenger traffic increased the fastest, and the average growth among 1998 and 2011 was 17.13%, following by the railway and road. The road passenger and turnover grew slowly around 2000, and developed faster after 2007. Affected by technical and economic characteristics and the rapid development of railways, highways, civil aviation, the water transportation passenger traffic showed downward trend on the whole year by year. Among the several main freight transport means, waterway stood out on the growth. The total freight volume and turnover of 2012 were 8 and 17.5 times of 1998 respectively. The water transportation occupied a high proportion, secondary to the road. And the railway freight basically maintained steady growth.

Table 1 the passenger and freight transport volume and turnover of Chongqing 1998-2012

Year	Passenger volume (ten thousand)	Passenger turnover (10 000 passenger km)	Freight volume (10 000 ton)	Freight turnover (10 000 ton-km)
1998	49020	2346281	25328	2684566
1999	52442	2434000	25190	2742000
2000	56969	2577859	26852	3063900
2001	59244	2662900	28212	3253200
2002	61918	2776900	29787	3376300
2003	58290	2526100	32565	3680300
2004	63495	2994200	36434	5180300
2005	60436	3018038	39200	6248968
2006	61228	3015761	42808	8213853
2007	77187	3938936	49973	10497955
2008	107191	4430156	63651	14864332
2009	114598	4814394	68491	16442995
2010	126804	5497718	81385	20103977
2011	141499	6808274	96782	25302835
2012	157798	7551314	110136	28310229

(The above data come from Chongqing 2013 Statistical Yearbook)
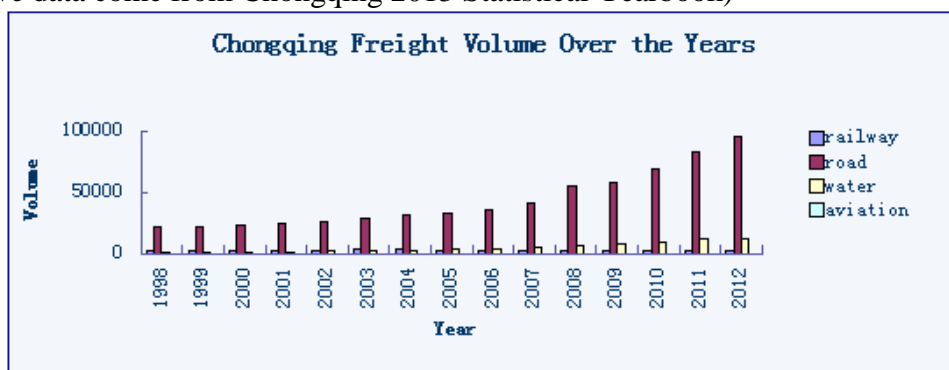

Figure 2 Chongqing freight volume over the years (10000 ton)

3.2 The changes of the transportation structure

Among the current Chongqing transportation structure, the road transportation remains the dominant position and the proportion tends to improve, especially in the passenger traffic. Close to 96.5% of passengers choose the road transport. On one hand, road transport is featured with "small quick and flexible" in passenger and freight transportation; on the other hand, the improvement of whole city road network provides the infrastructure security. In 2010 the Chongqing government put forward the "two loops and eight rays" and "8-hour Chongqing", which would lead to the continuous growth of road transport proportion in regional transport structure in the short term.

After being set municipality, the 3 main transports of highways, railways, waterways remained smooth growth in terms of passengers and freight. Lying in the intersection of the Yangtze and Jialing River, the water resources are convenient and further developed. The waterway transport freight turnover showed a rapid increasing trend and overweighed the rail transport. The road and railway freight turnover have been sustained steady growth, but rail transport fell behind highways, waterways and aviation in views of growth rate. As an advanced mode of transportation, civil aviation has become an indispensable force in the passenger and freight transportation. Therewith aviation takes an increasing proportion in the transport structure of Chongqing. With the expansion of Jiangbei International Airport and the construction of Qianjiang Zhoubai Airport, plus Wanzhou Wuqiao Airport, the advantages and potential of aviation will be further reflected and developed.
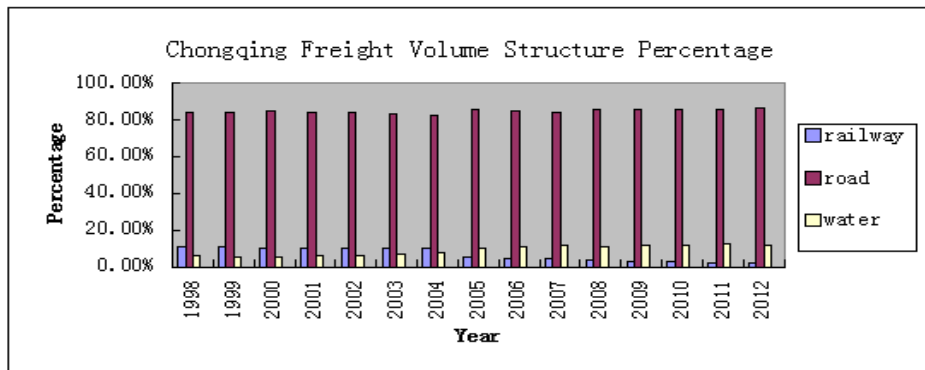
Figure 3 Chongqing freight volume structure percentages (10000 ton)

4. The Quantitative Analysis of Chongqing Transportation structure and Industrial Structure

4.1 The correlation analysis of transportation structure and industrial structure

National economy is closely related to transportation. With the economy sustained to develop, then the industrial structure also changes. Therefore different industrial structure ask for different transportation structure, and these two kinds of structure need to be in coordination. And such coordination relationship will help to analyze the detailed influences of industrial structure and predict the development of Chongqing transportation structure.

Grey relational analysis method mainly compares the geometric relationship of system data sequences to analyze the correlation degree of various factors in system, which would quantitatively describe the impact between the two. Therefore, we use the gray correlation theory to quantitatively analyze the relationship between Chongqing industrial structure and transportation structure.

Make the referring sequence and comparing sequence non-dimensional;

Due to the different physical meaning of various factors in the system, the data is not necessarily using the same dimension, which leads the sequences hard to compare or get the correct conclusion. In order to ensure comparability of the same and similar factors, the original data should be non-dimensional normalized using the equation (1). The larger the value of $x_i(k)$, the higher of the correlation degree. (i Means the year, and k stands for the corresponding factors);

$$x_i^{'}(k) = \frac{x_i(k) - \min x_i(k)}{\max x_i(k) - \min x_i(k)} \tag{1}$$

(2) Calculate the gray correlation coefficient of $\xi_i(k)$ of the referring sequence and comparing sequence. (ρ Means the resolution coefficient, used to equal 0.5)

$$\xi_i(k) = \frac{\min\limits_{i}\min\limits_{k}|x_0(k) - x_i(k)| + \rho \max\limits_{i}\max\limits_{k}|x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max\limits_{i}\max\limits_{k}|x_0(k) - x_i(k)|} \tag{2}$$

(3) We can obtain the correlation coefficient of the referring sequence and comparing sequence through calculation. Considering that there are a series of correlation coefficients and scattered information inconvenient to compare, so it is necessary to focus on these correlation coefficient of different time point. We calculate the mean value to present the correlation. And the correlation calculated as follows:

$$r_i = \frac{1}{N}\sum_{k=1}^{N}\xi_i(k) \tag{3}$$

Through the above calculation we can obtain the gray correlation degree of the Chongqing transportation structure and industrial structure from 1998 to 2012. And the detailed correlation degrees are shown in the following table 2.

Table 2 The gray correlation degree of the Chongqing transportation structure and industrial structure

		Passenger volume	Passenger turnover	Freight volume	Freight turnover
Railway	First industry	0.72	0.76	0.57	0.55
	Secondary industry	0.63	0.69	0.61	0.6
	Tertiary industry	0.67	0.76	0.63	0.6
Road	First industry	0.66	0.58	0.73	0.67
	Secondary industry	0.8	0.71	0.78	0.66
	Tertiary industry	0.76	0.66	0.75	0.65
Waterway	First industry	0.63	0.59	0.64	0.72
	Secondary industry	0.69	0.64	0.7	0.71
	Tertiary industry	0.68	0.62	0.66	0.72

We can see in the table 2, the freight volume and turnover of the railway and waterway is closely related to secondary industry in Chongqing, and less related to the first and tertiary industry. On the basis of the above analysis, we can draw the conclusion that the development of secondary industry could promote the further growth of railway and waterway transport. Due to the feature that most of the short-distance passengers prefer road transport, therefore the secondary and the tertiary industry is more correlated with the road passenger volumes than first industry. With the economy developing and resident incomes improving, more travailing demand wold stimulate the road transport to increase to some extent in the future.

4.2 Transport structure gray slope correlation analysis

Changes in the structure of transport not only stems from the adjustment of industrial structure, while the proportion varies form one transport to anther. We use gray correlation degree to quantitatively analyze the interaction and developing trend of the three main transport. Through calculation, we obtain the detailed gray correlation coefficients of the passengers and freight among the three transports.

Table 3 the gray slope correlation coefficients of passengers volume

	Railway	Road	Waterway
Railway	1.00	0.41	0.09
Road	0.41	1.00	0.32
Waterway	0.09	0.32	1.00

Table 4 The gray slope correlation coefficients of passengers turnover

	Railway	Road	Waterway
Railway	1.00	0.64	0.51
Road	0.64	1.00	0.28
Waterway	0.51	0.28	1.00

Table 5 The gray slope correlation coefficients of freight volume

	Railway	Road	Waterway
Railway	1.00	0.15	0.23
Road	0.15	1.00	-0.57
Waterway	0.23	-0.57	1.00

Table 6 The gray slope correlation coefficients of freight turnover

	Railway	Road	Waterway
Railway	1.00	-0.27	0.55
Road	-0.27	1.00	-0.53
Waterway	0.55	-0.53	1.00

From Table 3, Table 4 we can see that the road and railway are intently correlated and the correlation coefficient is negative. What's behind the data is that the Chongqing government has increased investment in the highway construction recently, which makes the road transport the first choice while traveling. The waterway transport flow has shrunk year by year for its own limitations, therefore it is lowly related with other transport. Form the table 5, we can figure out that the correlation coefficients are respectively 0.23 and 0.15 among various transports in freight transport.

The hiding reason is that different transports have their own advantages according to the economic characteristics of goods. On the contrary in table 6, the waterway transport is closely related with road and railway and the correlation coefficients are negative, which shows that the waterway has been gradually replaced by road and railway. Such replacement coincides with the changes of transportation structure.

5. Conclusion

Through the above analysis, we can obtain that the development mode of Chongqing transportation is closely linked with the three industries of regional economy. In general, the correlation coefficients between transports and three industries are small in views of passenger's transportation. But in the freight transportation, only the secondary industry is closely related with the three transports. The main resources of Chongqing economy development come from the secondary industry dominated by processing industry and the tertiary industry dominated by service industry. While predicting the transportation development in the future, we must take the current economy into consideration. With the aid of gray prediction and regression analysis, we could predict that the Chongqing passengers demand will reach 2.5 billion in 2020 and the railway, road and waterway transport would respectively share 7.85%, 89.93% and 1.06%. Similarly, the Chongqing freight demand will increase to 1.9 billion ton, and the railway, road and waterway respectively share 2.30%, 88.23% and 9.46%. From the above analysis and forecasting results we can obtain that the development of national economy and the evolution of industrial structure would exert an immeasurable influence on the development of passengers transport structure. In the passenger's traffic, the road and railway would remain and aggravate competing trends. And the road would still share the main force of passengers transport. In the freight transport, various modes of transport would coordinate the development of Chongqing transportation and perform their own function.

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