Research Article
The Correlation Analysis of Food Transportation Structure and Industrial Structure

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Abstract: National economy is closely related to the food transportation structure and the adjustment of industrial structure influences and changes the development of food transportation structure. Taking Jilin Province 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 food transportation modes, thus providing a theoretical basis for a reasonable forecast of transport development.

Keywords: Food transportation structure, grey correlation degree, industrial structure

INTRODUCTION

Food transportation structure reflects the development and scope of the regional food 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 food transportation structure to make the appropriate improvement. In recent years, Jilin Province 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 food transportation structure, the development of economy would inevitably bring the change the development of food transportation structure. Li (2000) analyzed how different factors influence the food transportation structure and mainly describe the evolution of food transportation structure from the qualitative point of view. Peng (2009) discusses the relationship between food transportation and industrial structure adjustment through qualitative analysis and points out that food transportation is the foundation of national economic development. And the influences changes according to economy and society. Li (2011) 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 (Li, 2011). Nie (2010) builds the complete decomposition model to analyze and predict the influences that industrial structure yield to food transportation structure. Chu (2009) preliminarily analyzes the correlation relationship between the development of Sichuan passenger and freight transport and industrial structure changes from gray system association mode. Feng *et al.* (2012) use the co-integration theory to study the long-term equilibrium relationship between passenger and freight traffic and the three industries. Wu and Shi (2006) analyzes such relationship by examining the entropy causality of industrial structure and food transportation structure. In this study, we will begin with the current situation of Jilin Province industrial structure, combined with structural changes of food transportation in recent years (Run, 2002) and then use gray correlation theory to quantify the influences in order to provide theoretical support for the Jilin Province food transportation future development strategy.

MATERIALS AND METHODS

The growth of Jilin Province GDP: Jilin Province 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% and an average annual growth value of about 73.7 billion yuan. These data show and reflect the high growth of Jilin Province society and economy; simultaneously such growths will effectively stimulate and promote the development of food transportation in this region.

Table 1: The passenger and freight transport volume and turnover of Jilin Province 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 Jilin Province 2013 Statistical Yearbook)

The adjustment of Jilin Province industrial structure: As shown in Fig. 1, the three major industries developed fast in Jilin Province, 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 Jilin Province GDP, the primary industry accounted for 7.9%, secondary and tertiary industries were 50.5% and 41.6%.
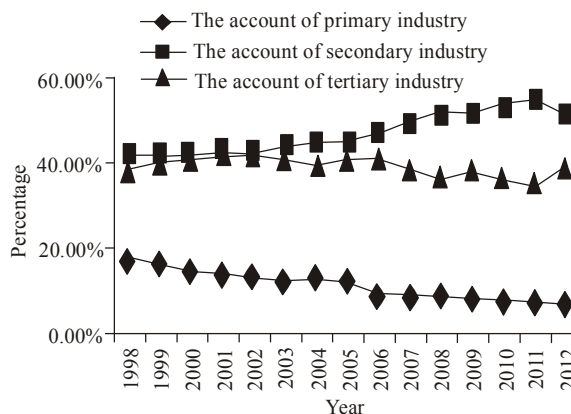
The changes of the total food transportation traffic: After a review of the historical data we can find an overall increasing trend in passenger and freight traffic and the cargo turnover stands out. Meanwhile, through observation we find that the growth rate has accelerated since 2000. The whole passenger 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%.As shown in Table 1.
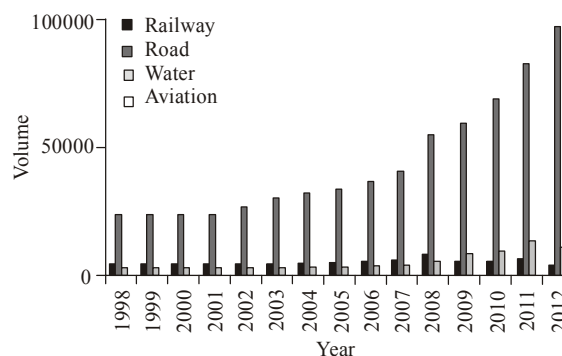
In terms of passenger traffic (Fig. 2), the traffic of road transport and aviation have maintained a rapid growth. The railway traffic and turnover showed an overall upward trend except the declination in 2005 for the railway segment redivided. The aviation passenger traffic increased the fastest and 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 food transportation passenger traffic showed downward trend on the whole year by year.

Fig. 1: The percentage of three industries in Jilin Province

Fig. 2: Jilin Province freight volume over the years (10000 ton)

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 food transportation occupied a high proportion, secondary to the road. And the railway freight basically maintained steady growth.

The changes of the food transportation structure: Among the current Jilin Province food transportation structure, the road food transportation remains the
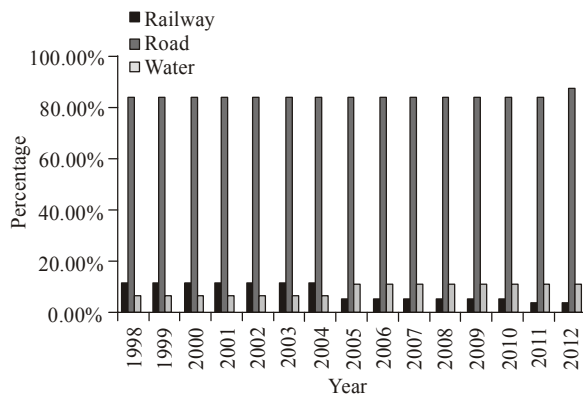
Fig. 3: Jilin Province freight volume structure percentages (10000 ton)

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 food transportation; on the other hand, the improvement of whole city road network provides the infrastructure security. In 2010 the Jilin Province government put forward the "two loops and eight rays" and "8-h Jilin Province", 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 food transportation, civil aviation has become an indispensable force in the passenger and freight food transportation. Therewith aviation takes an increasing proportion in the transport structure of Jilin Province. 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 (Fig. 3).

RESULTS AND DISCUSSION

The correlation analysis of food transportation structure and industrial structure: National economy is closely related to food transportation. With the economy sustained to develop, then the industrial structure also changes. Therefore different industrial structure ask for different food 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 Jilin Province food 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 Jilin Province industrial structure and food 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 Eq. (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):

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

(1)

- 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):

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}$$

(2)

- 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:

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

(3)

Through the above calculation we can obtain the gray correlation degree of the Jilin Province food 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 Jilin Province food 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	0.60
	Tertiary industry	0.67	0.76	0.63	0.60
Road	First industry	0.66	0.58	0.73	0.67
	Secondary industry	0.80	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

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

As we can see in the Table 2, the freight volume and turnover of the railway and waterway is closely related to secondary industry in Jilin Province 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 would stimulate the road transport to increase to some extent in the future.

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 from one transport to another. 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.

From Table 3 and 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 Jilin Province 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 food transportation structure.

CONCLUSION

Through the above analysis, we can obtain that the development mode of Jilin Province food 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 passengers food transportation. But in the freight food transportation, only the secondary industry is closely related with the three transports. The main resources of Jilin Province economy development come from the secondary industry dominated by processing industry and the tertiary industry dominated by service industry. While predicting the food 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 Jilin Province 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 Jilin Province 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 passengers 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 Jilin Province food transportation and perform their own function.

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