Research on the Relationship Between Regional Economy and Freight Transport Based on Factor Analysis

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Abstract. This paper analyses correlation between Regional Economy and Freight Transport by means of Factor Analysis. The article uses the expert interview method to determine what indicators should be considered during the Factor Analysis Model evaluation is established. The result shows that there are different kinds of relationships between each province’s economy and its freight transport. Some provinces’ economic aggregate are large, but with ordinary economic quality, so their freight demand mainly come from the traditional low-value-added industries. Some provinces have developed economies, their freight demand mainly come from high-value-added industries.

Introduction

After many years of development since the reform and opening up, China's economy has achieved rapid development. The total economic output increased from 458.76 billion yuan in 1980 to 82712.2 billion yuan in 2017, with an increase of 180 times. In the context of the provincial regional economy, the growth rate is equally astonishing. For example, in 1980, the GDP of Guangdong Province was 24.695 billion yuan, by 2017 it had increased to 8987.923 billion yuan, which was far more than the whole country’s growth rate. Compared to the eastern coastal areas, Jilin’s economic growth rate is relatively slow, and its status in the national economy is gradually declining. Trade will promote regional economic development, from the perspective of modern production, trade demand is a concentrated expression of market demand, which helps to increase the scale of production and professionalism. As a country with vast areas and huge differences, China’s provinces have large-scale trade in various regions and are increasingly dependent on freight transport. The role of transportation and cargo transportation capacity in regional economic growth is also becoming increasingly evident. Therefore, many scholars began to pay attention to the relationship between regional economy and transportation and freight transportation. Rostow thinks that transportation develops with the rise of commerce. There are many factors between economic development and off-site trade that will have an impact on regional economic development, Freight transportation is one of them.

Regional Economic and Freight Development Trends

Regional Economic Development Trends

At present, there are 31 provincial administrative divisions (excluding Hong Kong, Macao, and Taiwan regions) in China. In recent years, the pace of overall economic development in the country has been similar, and the economy of all provinces and regions has also maintained rapid development. According to the economic aggregate, the top five provinces in 2016 were Guangdong, Jiangsu, Shandong, Zhejiang, and Henan, and the last five provinces were Tibet, Qinghai, Ningxia, Hainan and Gansu. Comparing 1997 with 2016, there was no change in the top five provinces and the last five provinces of the national economy. Among the top five provinces, the gap between Guangdong and Jiangsu is relatively small, with Guangdong only leading 4%. The gap between other provinces is more obvious and the relative position will remain in a short period of time. The gap between the last five provinces is also obvious, and the current order will continue to be maintained in the short term. Among other provinces, Shaanxi, Inner Mongolia, Tianjin, Hubei,
Beijing, Hunan, Sichuan, Jiangxi, Guizhou, and Anhui rank in the advance; Heilongjiang, Liaoning, Yunnan, Shanxi, Shanghai, Jilin, Hebei, Xinjiang, Chongqing and Guangxi rank in the recession; Fujian remains unchanged.

According to the calculation of per capita GDP in 2016, the top five provinces in China were Beijing, Shanghai, Tianjin, Jiangsu, and Zhejiang. The last five were Gansu, Yunnan, Guizhou, Tibet and Shanxi respectively. Compared with 1997, Shaanxi, Inner Mongolia, Ningxia, Hubei, and Chongqing rank ahead by more than 5 places; Heilongjiang, Xinjiang, Hebei, Yunnan, and Liaoning have Sorted back not less than 5 places. In summary, the economic development of the Yangtze River basin in the South has been rapidly in the past 20 years. The development in the Beijing, Tianjin, Inner Mongolia and Shaanxi provinces have been well developed, while the overall performance in the Northeast were poor.

Regional Freight Development Trends

With the rapid development of China’s economic aggregate, the volume of cargo traffic has also grown rapidly. In 1997, the amount of cargo transported in China was 127.82 million tons, of which railway transportation volume was 172.149 million tons, accounting for 13.5%; the volume of road freight was 976.36 million tons, accounting for 76.4%; The water transportation volume was 113.06 million tons, accounting for 8.9%; The civil aviation cargo volume was 1.25 million tons; the pipeline cargo volume was 16,002 tons, accounting for 1.3%. In 2016, the total cargo volume was 438.763 million tons, which was 3.43 times that of 1997. Among them, the fastest growing rate was water transport volume, which was 5.63 times that of 1997; Followed by civil aviation cargo volume, which was 5.34 times that of 1997. The increase in the volume of pipeline transportation also exceeded the average growth rate of freight volume; The growth rate of railway freight volume is obviously lower than the average growth rate of freight volume. The growth rate of road freight volume is basically the same as the average growth rate. The five slowest growing provinces were Beijing, Heilongjiang, Jilin, Tianjin and Shanxi; The five fastest growing provinces are Tibet, Anhui, Ningxia, Guizhou and Jiangxi. Among the slowest growing provinces, Heilongjiang, Jilin, and Shanxi all had poor economic performance.

Empirical Analysis

Factor Analysis Principle

Factor analysis was proposed by Charles Spearman in 1904. After perfection, it eventually became an important branch of modern statistics. Factor analysis integrates variables with intricate and complex relationships into a small number of factors to discover the relationship between the original variables and factors, explore multiple measures that can be measured directly, and how measured indicators with certain correlations are affected by a few intrinsic factors. The independent factors of the dominance, and when conditions permit, can be used to classify variables.

Factor analysis finds out a few random variables by studying the internal dependency of the correlation coefficient matrix among multiple variables, and achieves the purpose of synthesizing the main information of all variables. We call these random variables variables. Each factor is not related to each other and all variables can be expressed as a linear combination of common factors. Suppose there are N samples, P indicators, \( X = (x_1, x_2, ..., x_p)^T \) is a random vector,

The common factor is \( F = (F_1, F_2, ..., F_m)^T \)

The factor model expression is:

\[
X_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1m}F_m + \varepsilon_1 \\
X_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{2m}F_m + \varepsilon_2 \\
\vdots \\
X_p = a_{p1}F_1 + a_{p2}F_2 + \cdots + a_{pm}F_m + \varepsilon_p
\]

The coefficient matrix \( A = (a_{ij}) \) is factor loading matrix. The factor load \( a_{ij} \) is the correlation coefficient between the common factor \( F_i \) and the variable \( X_j \). \( \varepsilon \) is a special factor that represents
the variation caused by factors other than the common factors. After calculating the common factors, you can use regression estimation and other methods to find the mathematical model of the factor score. Then, the common factor is expressed as the linear form of the variable, and the factor score is calculated accordingly so that the case can be comprehensively evaluated.

\[ F_i = b_{i1}X_1 + b_{i2}X_2 + \cdots + b_{in}X_n \quad (i=1, 2, \ldots, m) \]

**Indicator Selection**

When factor analysis is used to study the relationship between China's regional economy and freight transportation, we must first determine the evaluation indicators. GDP is the most common evaluation indicator of regional economy. According to common classification methods, there are primary industry, secondary industry and tertiary industry. The demand of different industries for the transportation of goods differs significantly. Therefore, the corresponding value-added shall be recorded as \( X_1, X_2, \) and \( X_3 \) as the evaluation indicators of the regional economy. Freight transportation reflects the results of regional cargo transportation. According to common cargo transportation types, there are rail freight, road freight, water freight, civil aviation freight and pipeline freight. Considering that the volume of civil aviation freight and pipeline freight is relatively small and data are difficult to obtain, so we select the rail freight, road freight and water freight as indicators of freight volume, respectively recorded as \( X_4, X_5, X_6 \); The situation of regional freight transportation is affected by the capacity of transportation infrastructure. Therefore, the mileage of railway operations, the mileage of high-grade highways, the tonnage of trucks used for road operations, the mileage of inland waterways, and the net load of motor ships are selected as indirect indicators of the freight situation, respectively recorded as \( X_7, X_8, X_9, X_{10}, X_{11} \).

All the indicator data come from the annual statistical data obtained by the National Bureau of Statistics from provinces and regions. The target countries are 31 provinces, autonomous regions, and municipalities directly under the Central Government (excluding Hong Kong, Macau, and Taiwan), and the time is 2016.

**Factor Analysis**

Enter the selected indicator data into SPSS23, Select "KMO" and Bartlett's sphericity test in the "Description" dialog box; In the “Extract” dialog box, select the “scree plot” in the Output options group. The applicability test results of factor analysis are shown in Table 1. According to the output results, the KMO statistic is 0.726, which is greater than 0.7, indicating that the information overlaps among the variables is high and tested by hypothesis. Therefore, this case is more suitable for the factor analysis model.

| Table 1. KMO and Bartlett’s Test. |
|-----------------------------------|
| Kaiser-meyer-0lkin Measure of Sampling Adequacy. | 0.726 |
| Bartlett’s Test of Sphericity | Approx. Chi-Square | 340.321 |
| df | 55 |
| Sig. | .000 |

| Table 2. Communities. |
|------------------------|
| Initial | Extraction |
| X1 | 1.000 | 0.792 |
| X2 | 1.000 | 0.888 |
| X3 | 1.000 | 0.768 |
| X4 | 1.000 | 0.512 |
| X5 | 1.000 | 0.828 |
| X6 | 1.000 | 0.801 |
| X7 | 1.000 | 0.795 |
| X8 | 1.000 | 0.783 |
| X9 | 1.000 | 0.635 |
| X10 | 1.000 | 0.616 |
| X11 | 1.000 | 0.751 |
The data in Table 2 is the common factor variance, which reflects the extent to which the common factor contained in each variable can be extracted. The data shows that the common degree of most of the variables is more than 70%. Therefore, the common factors extracted by the default number are used. Each variable has a certain ability to interpret. In this paper, two common factors are extracted according to the default criteria with eigenvalue greater than 1. According to the observation of gravel chart, it is more appropriate to select the first two common factors.

Choosing F1 and F2 as common factors, their cumulative variance contribution rate is 74.284%, which can reflect most of the information of the original variable, and can thus make an overall assessment of regional economic and freight relations.

The factor analysis model can be obtained from the data in spss23. The data in the table shows that the added value of the second industry (X2), the added value of the tertiary industry (X3), the amount of water transportation (X6), and the payload of the motor boat (X11) are more heavily loaded on the first common factor F1. These indicators more sensitively reflect the economic and freight changes after rapid economic development. They can be named economic and freight development factors; primary industry added value (X1), road freight (X5), railway operating mileage (X7), and high The graded highway mileage (X8) and the tonnage of the trucks used for road operation (X9) have a relatively large load on the second common factor F2, which can be referred to as basic economic and freight factors.

Table 3 is the component score coefficient matrix, from which you can write the expression for each common factor:

\[
F_1 = 0.155Z_{X1} + 0.168Z_{X2} + 0.149Z_{X3} + 0.018Z_{X4} + 0.157Z_{X5} + 0.123Z_{X6} + 0.062Z_{X7} + 0.129Z_{X8} + 0.129Z_{X9} + 0.122Z_{X_{10}} + 0.117Z_{X_{11}}
\]

\[
F_2 = 0.088Z_{X1} - 0.053Z_{X2} - 0.111Z_{X3} + 0.271Z_{X4} + 0.1Z_{X5} - 0.221Z_{X6} + 0.315Z_{X7} + 0.198Z_{X8} + 0.135Z_{X9} - 0.15Z_{X_{10}} - 0.22Z_{X_{11}}
\]

Table 3. Rotated Component Matrix.

| Component | 1     | 2     |
|-----------|-------|-------|
| X1        | .155  | .088  |
| X2        | .168  | -.053 |
| X3        | .149  | -.111 |
| X4        | .018  | .271  |
| X5        | .157  | .100  |
| X6        | .123  | -.221 |
| X7        | .062  | .315  |
| X8        | .129  | .198  |
| X9        | .129  | .135  |
| X10       | .122  | -.150 |
| X11       | .117  | -.220 |

According to the rotated factor load matrix, the factor scores were calculated using the Bartlett factor score method in SPSS23, and the comprehensive evaluation function was constructed by taking the proportion of the variance contribution rate of each common factor to the total variance contribution ratio of the two common factors as the weight.

Table 4. Comprehensive score sheet.

| Ranking | Province | FAC1_1 | FAC2_1 | Score |
|---------|----------|--------|--------|-------|
| 1st     | Shandong | 1.74085| 0.94882| 1.49  |
| 2nd     | Guangdong| 2.29946| -0.66974| 1.35  |
| 3rd     | Hebei    | 0.88043| 1.64086| 1.12  |
| 29th    | Ningxia  | -1.28188| -0.45967| -1.02 |
| 30th    | Hainan   | -1.29214| -0.80819| -1.14 |
| 31th    | Xizang   | -1.55476| -0.85497| -1.33 |
Table 4 shows the ranking of the top three and bottom three provinces based on factor scores. According to the ranking results, it can be seen that the overall score is basically consistent with the level of economy and freight in each province. In the top three, Shandong scored higher on both the common factor 1 and the common factor 2, which is in line with Shandong’s status as a large economic province and a large agricultural province, and its transportation infrastructure is also relatively complete. One; Guangdong performed best on the common factor 1, far more than other provinces and regions, indicating that Guangdong’s second and third industries are more developed, water transport is also more convenient, but the public factor 2 score is poor, but also with Guangdong's primary industry is not Prominently, the mileage of railways is not so prominent; Hebei Province, which is rather special, ranks third in total scores, but scores on the common factor 1 are not excellent. They mainly rely on the common factor 2, indicating the quality of current economic development in Hebei Province. Not high, but also in the basic industry-based stage. The latter three provinces and districts are all regions with relatively small economic aggregates and relatively backward development in China. They score very poorly on the common factor 1 reflecting the quality of economic development, and also score on the common factor 2 that reflects the basic performance of the economy and freight. Lower, therefore, the overall ranking is behind.

Conclusions
The above research shows that the level of development of the economy and freight capacity of various provinces and regions in China is quite different. In general, the freight capacity of regions with higher levels of economic development is also better, and vice versa. However, there are still several different types of provinces and autonomous regions. One is an area with large economic aggregates and good economic quality. For example, Guangdong, Jiangsu and other places, the regional economy is mainly driven by the second and third industries, and the demand for freight transportation is relatively flexible. In addition to the traditional railway and road transport, water transport plays an increasingly important role. For these types of provinces and regions, while strengthening the traditional railway, highway and other modes of transport, we must pay more attention to the construction of diversified modes of transport, especially It is necessary to increase the investment in water transport and civil aviation infrastructure so as to adapt it to the regional economic development and provide protection for the local economy. One is that the economic aggregate is large, the economic quality is general, and the freight demand mainly comes from the traditional low-value-added industries. The traditional transportation modes such as railways still occupy an important position, such as Hebei Province, etc. For this type of region, accelerating economic transformation and improving economic development Quality is a top priority. With respect to freight facilities, it is still necessary to strengthen the investment in traditional transportation infrastructure. The other is the traditional underdeveloped provinces and regions, with relatively small economic quality and economic aggregates, as well as lack of transport infrastructure, such as Tibet and Ningxia. For such areas, it is necessary to vigorously develop basic industries and improve the economy. The total amount, on the other hand, also needs to strengthen infrastructure investment and provide necessary support for local economic development.

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