Research on the Development Trend of Guanghan Railway Freight Transport Based on GM (1,1) Model

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Abstract. Railway transportation occupies a leading position in our country's economic construction, especially the city plays an irreplaceable important role in the transportation of bulk goods and long-distance goods, is an important part of our economic development.In this paper, the development trend of freight transport in Guanghan railway station is taken as the research object. Firstly, the advantages and influencing factors of the development of freight transport in Guanghan railway station are analyzed, and then the GM (1,1) model is used to forecast the 2023-20272027, the residual analysis shows that the average relative error is 0.99% , less than 1% , which indicates that the prediction result is effective. Finally, on this basis, the paper puts forward the relevant countermeasures and suggestions for the key influencing factors of the development trend of Guanghan freight station.

Keywords: Freight volume; influencing factors; GM (1,1) model

1 Introduction

At present, the railway transport industry is facing more and more fierce competition. The supply and demand pattern of railway freight transportation in our country is gradually inclined from bulk goods to consumer logistics, that is, the demand for bulk goods is gradually declining, while consumer logistics is an explosive growth trend. [1]At the same time, the new changes of the main social contradictions in the new era have put forward new requirements for the railway freight transport work, “Door-to-door transport”, “Full supply chain” and other modern logistics services emerged, railway freight gradually towards seamless and integrated. It shows the trend of“Overall growth, proportion fluctuation” in our railway transportation system. On the one hand, the overall volume of railway freight is showing a low-speed growth trend. On the other hand, the proportion of railway freight traffic in the five modes of transport has shown a large fluctuation, and since 2020, the proportion of railway freight traffic has shown a downward trend, the railway transport system is facing great challenges.[2]

At present, many scholars have studied the influencing factors and related prediction methods of railway freight volume.For example: in order to analyze the degree of influence of railway internal factors on freight volume, need to establish the mapping relationship between freight volume and various factors, and analyze its sensitivity, the use of artificial neural network can imitate the processing mode of a large number of neurons in the human brain that are connected to each other, parallel information, through the learning of a certain number of data samples, establish a multi-parameter, nonlinear mapping relationship between input and

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output data.[3-4]In order to ensure the accuracy of the forecast, Jiang Xinli used the data of the whole society freight volume and railway freight volume in Shanxi Province from 1997 to 2002. On the basis of the grey prediction theory, the GM(1,1) forecasting model is used to forecast the freight volume from 2003 to 2007. After the accuracy test, the model has high accuracy. [5]Z Lang proposed that the influencing factors of railway freight volume can be analyzed from natural conditions, social economy and other aspects. After analysis, it is concluded that the bulk material output, the number of railway wagons, and the mileage of railway operation are the factors with a high degree of influence. [6]

But few studies have been carried out for specific stations. Due to the different traffic advantages and geographical location of each station, different goods sources, the impact factors of freight volume of each station are necessarily different. Therefore, taking Guanghan railway station as an example, the study on the development trend of railway freight volume at specific freight stations and the analysis of its influencing factors will be very important to the overall development of our railway freight transport system.

2 Analysis of factors influencing the development of freight transport in Guanghan railway station

2.1General situation of freight transportation at Guanghan Station

Guanghan station is located in Guanghan, Deyang City, Sichuan province. From the point of view of cargo source and traffic, the development of freight transport in Guanghan Station has the following advantages:

Guanghan station is rich in bulk goods. First, Guanghan's rapid industrial development, rail transport bear equipment manufacturing industry and new energy industry of goods distribution. Second, Guanghan, identified as “The country's second demonstration county to take the lead in fully mechanized production of major crops”, produces large amounts of bulk goods such as rice, wheat and fertiliser.

The traffic advantage of Guanghan station is remarkable. Chengdu-lanzhou railway, Chengdu-chengdu high-speed railway, Baoji–Chengdu Railway line and Guangyue line run across the whole territory and have an important position in the development of intermodal transport.

Guanghan station railway transport goods source distribution equilibrium. First, it is mainly responsible for the cargo transportation between the freight port of Banliedeyang in the Central European Union and the international container port of Qingbaijiang in China; second, it is responsible for the cargo distribution between the urban center area and the industrial heavy loading zone; third, it is responsible for the cargo transportation between the urban center area and the industrial heavy loading zone, to undertake cargo transportation between equipment manufacturing industry and new energy industry.

2.2 Analysis of factors affecting freight transport development

Macro factors:ailway transport at Guanghan railway station is closely related to economic development. The macro-economic impact on the development of railway freight transport

can not be underestimated. First, the gross national income (GNI) , which can reflect the overall economic activity, will increase the purchasing power of the whole population, thus increasing the freight volume of the whole society, thus increasing the freight volume of the railway. Second, the gross domestic product, can reflect the national or regional economic strength and the size of the market. Gross domestic product growth is accompanied by an increase in consumption capacity and an active freight transport system. Third, the population, can reflect the total consumption of the country, thus causing changes in the volume of railway freight. Fourth, the value-added of agricultural production. Guanghan is a region with relatively rich agriculture. A large number of related products will be transported by rail because of its large loading capacity, strong transport capacity and fast train speed, fifth, the added value of industrial production. Railway development is vital to industrial development. Industrial development depends on railway freight transport to a certain extent.

Micro factors:One is Deyang's phosphate production. As a modern industrial city, Deyang's mineral resources are also essential to its development. There are 40 types of proven reserves in Mianzhu, of which phosphate rock is abundant and one of the four major phosphate rock producing areas in China. According to the official website of Deyang City People's government published data, phosphate rock production in 2017 after a sharp decline, fluctuations. The transport of phosphate rock is mainly by railway, so the production of phosphate rock in Deyang is identified as one of the factors affecting the development trend of freight transport at Guanghan railway station. Second, Deyang's output of rice, wheat flour, fodder and fertiliser has been increasing year by year. This kind of goods mainly chooses the railway transportation, thus to the freight volume influence is big. Third, Deyang's output of crude steel, steel and cement. Deyang is the largest steel manufacturing base, steel production continues to grow, and in order to promote structural reform, focus on the task of reducing overcapacity, the decision-making department in Deyang responded positively and took the initiative to reduce excess capacity. For railway freight, this will certainly affect the freight volume of Guanghan railway station.

Influencing factors of logistics environment change:In terms of logistics environment changes, only road transport is considered in the light of the topographical constraints of Deyang. The first is the volume of goods transported by road in Deyang, which has many advantages over rail transport. For example, road transport covers a wide area and is more conducive to providing door-to-door transport Highway transportation procedures such as simple. Therefore, with the improvement of People's quality of life, the national requirements of railway transport, there will be a large part of the freight traffic to the road. Second, Deyang's road transport freight turnover, which is an important indicator for the transport sector in the process of planning and economic assessment, has shown an overall upward trend in recent years, it has great influence on the development of railway freight transport.

3 Freight Volume Forecast of Guanghan Station Based on Gm (1,1) Model

3.1 Introduction to the model

GM (1,1) model is one of the main forecasting methods about grey system theory. It has the properties of differential, difference and index. It can reduce the randomness of the original data and make the characteristic law of the result more obvious. In the model, based on the original time series, the cumulant generated columns are obtained by cumulant, and the adjacent mean generated columns are generated by the cumulant generated columns. On the basis of calculating the development coefficient A and the grey action quantity B, the time response function is solved. Finally, the data were restored and the predicted results were obtained.See formula(1-12) for specific prediction steps.

Step 1: generate the original time series from the raw data collected:

$$X^{(0)}(k)=\left(x^{(0)}(1),x^{(0)}(2),x^{(0)}(3),\ldots x^{(0)}(n)\right) \tag{1}$$

Step 2: Based on the original time series, the data in each sequence is accumulated in turn to generate an accumulative generating sequence:

$$X^{(1)}(k)=\left(x^{(1)}(1),x^{(1)}(2),x^{(1)}(3),\ldots,x^{(1)}(n)\right) \tag{2}$$

Step 3: according to the cumulative generation of data series, adjacent to the two data mean value, get adjacent to the mean value of the series:

$$\mathrm{Z}^{(1)}(\mathrm{k})=\frac{1}{2}\left(x^{(1)}(k)+x^{(1)}(k-1)\right),k=2,3,\ldots,n \tag{3}$$

$$Z^{(1)}(\mathrm{k})=\left(Z^{(1)}(2),Z^{(1)}(3),Z^{(1)}(3),\ldots,Z^{(1)}(n)\right) \tag{4}$$

Step 4: Based on the least squares, calculate the parameter vector u of the GM (1,1) model:

First, a Y-matrix of raw sequence values:

$$Y=\begin{bmatrix}\mathrm{x}^{(0)}(2)\\ \mathrm{x}^{(0)}(3)\\ \mathrm{x}^{(0)}(4)\\ \mathrm{x}^{(0)}(5)\end{bmatrix} \tag{5}$$

Then, the data from the adjacent mean series form a B matrix:

$$B=\begin{bmatrix}-Z^{(1)}(2),1\\ -Z^{(1)}(3),1\\ -Z^{(1)}(4),1\\ -Z^{(1)}(5),1\end{bmatrix} \tag{6}$$

Finally, after calculation, the parameter vector is obtained:

$$U = \begin{bmatrix} a \\ b \end{bmatrix} = \left(B^T B\right)^{-1} B^T Y \tag{7}$$

Step 5: Substitute A and B for differential equation:

$$\frac{d_{x^{(1)}(t)}}{d_{(t)}} + a\,x^{(1)}(t) = b \tag{8}$$

Step 6: solve for the differential equation and turn it into a non-homogeneous function:

$$\hat{x}^{(1)}(k) = \left(x^{(1)}(1) - \frac{b}{a}\right)e^{-a(k-1)} + \frac{b}{a} \tag{9}$$

Step 7: Regress the data to get the projections:

$$\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1) \tag{10}$$

tep 8: residual test. According to the GM (1,1) prediction model, the corresponding prediction model simulation sequence is obtained through the accumulative reduction:

$$\hat{x}^{(0)}(k) = \left(\hat{x}^{(0)}(1), \hat{x}^{(0)}(2), \hat{x}^{(0)}(3), \ldots, \hat{x}^{(0)}(n)\right) \tag{11}$$

The residual data are obtained by subtracting the original sequence from the simulated sequence and taking the absolute value:

$$E^{(0)}(k) = \left|x^{(0)}(k) - \hat{x}^{(0)}(k)\right| \tag{12}$$

This gives the relative error:

$$e(k) = \frac{E^{(0)}(k)}{x^{(0)}(k)} * 100\% \tag{13}$$

The average relative error of the forecasting data can be calculated by averaging the values in the series of relative error. In the practical study, the average relative error is less than 10% , which means the forecasting data is effective.

3.2 Case study-freight volume forecast of Guanghan railway station

According to data published on the official website of the Deyang Municipal People's government and in the annual statistical report on Guanghan's national economic and social development for 2018-2022, the historical data of railway freight volume of Guanghan railway station from 2018 to 2022 are summarized in table 1:

Table 1. railway freight volume of Guanghan railway station from 2018 to 2022

Year	2018	2019	2020	2021	2022
Freight volume (10,000 tons)	193.98	220.77	234.23	239.75	244.5

According to the calculation process in 3.1, the estimated freight 2027 for 2023-2027 are: 2,538,700 tons, 2,621,300 tons, 2,706,500 tons, 2,794,500 tons, 2,885,400 tons.

3.3 Residual test

Let k = 1,2,3,4,5 be added into the calculated GM (1,1) model, and then through the cumulative reduction, the 2027 railway freight volume forecast for 2023-2027 is obtained, that is, the simulated data of the prediction model. Combined with the actual railway freight volume data of Guanghan station from 2018 to 2022. The residual error is obtained by subtracting the original data from the simulated data. Then the relative simulation error is calculated. The calculated sequences are shown in table 2:

Table 2. residual test process data

Serial number	Actual data	Simulated data	Residuals	Relative simulation error
1	220.77	223.37	-2.6	1.18%
2	234.23	230.63	3.6	1.54%
3	239.75	238.13	1.62	0.68%
4	244.5	245.88	-1.38	0.56%

According to the calculated relative simulation error, it is not difficult to conclude that the average relative error is 0.99% , less than one percent. It shows that the prediction result is effective and has high reference value.

3.4 Analysis of freight development trend based on forecast results

Through the GM (1,1) model, the freight volume of Guanghan Station is predicted to be 2027 from 2023 to 2027. On this basis, in view of the key factors affecting the development trend of freight transport in Guanghan railway station, the following countermeasures and suggestions are put forward:

To secure the bulk of Deyang's cargo. Deyang's production of bulk goods rice, feed and fertiliser is at the heart of Guanghan's railway freight volumes, and increasing Deyang's production of bulk goods is one of the key measures to increase and stabilise freight volumes at Guanghan station.

Improve the railway freight logistics system, improve the“Door-to-door” transport services. Deyang's steel and crude steel production is a central factor in railway freight volumes at the Guanghan railway station, and the steel industry's most basic requirement for rail transport services is “Door-to-door” transport, in order to stabilize the freight volume of Guanghan railway station, the railway transportation should develop to the market and logistics mode. Constantly expand the“Door-to-door” transport scope, and thus facilitate the real-time sharing of information resources. Through the process reengineering of the whole transportation process, the total cost of transportation is reduced and the market share of transportation is enlarged.

Simplify business processes. If we want to attract more goods, we must simplify the business process and make it easy for shippers to receive or send goods, so as to enhance the competitiveness of railway transportation. At the same time, with the progress of our society and the improvement of residents' lives, the rapidity of cargo transportation becomes more and

more important. Therefore, railway freight transport also needs logistics equipment configuration, real-time information synchronization system, logistics tracking technology and other aspects of in-depth optimization research.

To achieve multi-party cooperation. Consider promoting the competitiveness of railway transportation through multi-party cooperation. Efforts to form a railway, highway, logistics supply chain integration management model. Build a multi-party cooperation, the common benefit of the transport system.

4 Conclusions

Based on the historical data from 2018 to 2022 and the GM (1,1) forecasting model, this paper forecasts the freight volume of Guanghan station in the next 5 years. The average relative error is 0.99% by the residual test, to get the next five years Guanghan station cargo volume: 2,538,700 tons, 2,621,300 tons, 2,706,500 tons, 2,794,500 tons, 2,885,400 tons. It can be seen that Guanghan station's future freight volume growth is slow and the growth rate fluctuates greatly. On this basis, some suggestions on the development trend of Guanghan railway station are put forward.

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