A Forecast Model for Rail Freight Volume Based on Improved GM(1,1) Model

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Abstract

In order to further study the development and change rules of railway freight volume and accurately predict the future freight volume by using relevant theories, a GM(1,1) freight volume prediction model based on the idea of equal dimensional complementarity is proposed in view of the low accuracy of the traditional GM(1,1) model. By comparing the average relative error of prediction results in 2012 and 2013, it can be known that the optimal dimension of this model is 7. The results show that the accuracy of the 7-dimensional prediction model is higher than that of the linear prediction model, the traditional GM(1,1) model and the modified GM(1,N) model compared with the different prediction models established based on the original data. It can be seen that this model not only has the advantages of simple calculation, applicability and high practicability, but also has reference significance for formulating reasonable and feasible railway freight planning scheme.

Keywords

Grey model, Iso-dimensional complementary model, freight volume forecast.

1. Introduction

With the continuous development of China's social economy, the logistics industry, known as the “gold industry in the 21st century”, also shows great development potential[1]. According to the freight volume index can not only reflect the development status of China's logistics industry, but also provide reasonable and accurate basis for forecasting China's logistics demand. As one of the main modes of freight transport in China, the freight volume of railway freight transport can reflect the great demand of China's national economy in terms of railway freight transport. How to study and analyze the development trend of freight volume by reasonable methods and predict the future railway freight volume by scientific prediction theory is of great practical significance for improving the efficiency of railway transportation and adopting effective measures to regulate the freight volume.

Many foreign scholars use different prediction models or data processing prediction methods to predict the future freight volume. For example, the box-jenkins model constructed by Cullinane[1] et al. has a small error and is very suitable for predicting short-term freight volume. Klodzinski[1]studied the historical data of freight volume of a port in the United States through scientific and reasonable analysis, and established a forecast model of freight volume based on manual audit network. In addition,Park[1]established different prediction models by using four different methods, such as exponential smoothing and Taylor series expansion, and described the advantages and disadvantages of each model by means of comparative analysis.

Compared with foreign developed countries, Chinese scholars predict logistics Starting late and practical experience is not mature, but many scholars and experts have made good research results after continuous efforts. Wu huawan et al.[2] proposed a railway freight volume prediction method based on RBF neural network, which not only has a far higher prediction accuracy than BP neural network, but also has unique advantages such as easy memory. Tao hailong[3]adopted the theory of applying intelligent hybrid algorithm to railway freight volume prediction model, and established a freight volume prediction model based on ipso-gnn[4]. Zhu wentong[5] proposed a railway freight volume forecasting method based on improved BP neural network.

Freight transport system is a complex system with multiple factors, multiple levels and multiple objectives. The development and changes are uncertain, and the index data are often incomplete, so the freight transport system is a typical gray system[6]. Therefore, relevant theories can be applied to study its internal rules and thus to dig up potentially valuable information. Traditional constructed according to the grey theory GM (1, 1) prediction model is often only for a moment is now close the data accuracy is higher, and the prediction accuracy is low for distant data and can reflect the trend of the change in order to solve the traditional GM (1, 1) prediction model deficiencies, this article thought of equidimensional filling vacancies can be incorporated into the traditional GM (1, 1) model, is proposed based on grey long-term freight volume forecasting model of equidimensional filling vacancies. Through practical case analysis, the accuracy of this model is verified to be better than that of the linear prediction model and the modified GM(1,N) model proposed in literature [1], which is suitable for long-term freight volume prediction and provides certain reference significance and reference value for other experts and scholars to study freight volume prediction methods.

2. GM(1,1) gray model

GM (1,1) model is a general form of gray model.The basic theories of GM (1,1) model are summarized as follows:

Set to $X^0 = x^{(0)}1\ x^{(0)}2 \ldots x^{(0)}\ n$ the characteristics of the railway carriage of goods by grey system data sequence, $X^{(1)}$ for X^0 the first order accumulated sequence, $i = 1,2,3,\ldots,n$, Z^1 as $X^{(1)}$ close to the mean generating sequence, says

$$x^{(0)}(k) + az^{(1)}(k) = b \tag{1}$$

is GM (1,1) grey differential equation, $z^{(1)}\ k = 0.5x^{(1)}\ k + 0.5x^{(1)}\ k-1$, $k = 1,2,3,\ldots,n$, $-a$ is the system development coefficient, b is the grey action.Assume $\xi = [a,b]^T$ is the parameter column,

$$Y = \left[x^0(2), x^0(3), x^0(4), \ldots, x^0(n)\right]^T \tag{2}$$

$$B = \begin{bmatrix} -\frac{1}{2}\ x^1(1) + x^1(2) & 1 \\ -\frac{1}{2}\ x^1(2) + x^1(3) & 1 \\ \cdots & \cdots \\ -\frac{1}{2}\ x^1(n-1) + x^1(n) & 1 \end{bmatrix} \tag{3}$$

Then parameter column $\xi = [a,b]^T$ can be obtained by least squares estimation $\hat{\xi} = B^T B^{-1} BY$.

Then, the approximate time response formula of GM (1,1) model is

$$x^{(1)}(k+1) = (x^{(0)}(1) - b/a)\ e^{-ak} + b/a,\ k = 1,2,3,\ldots,n \tag{4}$$

$$x^{(1)}(0) = x^{(0)}(1) \tag{5}$$

$$x^{(0)}(k+1) = (x^{(1)}(k+1) - x^{(1)}(k),\ k = 1,2,3,\ldots,n \tag{6}$$

3. Improve GM(1,1) railway freight volume prediction model

The traditional grey GM(1,1) model can be established by combining the fitting idea with the grey model which is based on the time series and the grey model which is a graph region with continuous and approximate curves intersection. It can be seen that GM(1,1) model only has high prediction accuracy and practical significance for partial data with relatively close time. Therefore, to improve the accuracy of the predicted value, it is necessary to add new information to improve the whiteness of the gray plane to reduce the area of the gray plane.

There is a certain relationship between the historical freight volume data and the forecast time data, but the freight volume is in the dynamic change, so it is more valuable to use the freight volume data close to the forecast time to improve the forecast accuracy. Based on this, this paper proposes a GM(1,1) railway freight volume forecasting model with equal dimensions.

Suppose the original number is listed as $X^{(0)}=(x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n))$, add the latest data obtained according to the model prediction to the original number and remove the original $x^{(0)}(1)$ to form the latest data column

$$X^{(0)}=(x^{(0)}(2), x^{(0)}(2), \ldots, x^{(0)}(n+1)),$$

and so on, repeat the model steps until the data needed for the target year is solved, and the calculation ends.

4. Case analysis

Freight volume prediction models of different dimensions are established respectively based on the data of freight volume of a city from 2005 to 2011 (table 1) as the original sequence. In addition, the freight volume data of 2012 and 2013 are taken as reference values to test the model error. After calculation, the average relative error of the model with different dimensions can be obtained, as shown in Table 2.

Table1 Original data statistics of freight volume from 2005 to 2011 in a city

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
freight（t）	5972.19	6263.81	6839.45	7206.66	7358.27	8053.98	8907.7	9671.89	10490.84

4.1 3.1 Optimal dimensional freight volume prediction model

The prediction model of 5-dimensional, 6-dimensional and 7-dimensional freight volume was established, and the freight volume in 2012 and 2013 was predicted according to the different dimensional models established. The accuracy of the model was tested by comparing the average error between the predicted value and the actual value, and then the optimal prediction model of freight volume was selected. The analysis of table 2 shows that the accuracy of the 7-dimensional prediction model is higher than that of the other two models.

Table2. Comparison of average relative error of freight volume in 2013 in different dimensions

Dimensions	Five dimensions	Six dimensions	Seven dimensions
Mean relative error	4.93%	4.76%	3.66%

4.2 3.2 comparison of prediction results of different prediction models

Based on the original data of freight volume from 2005 to 2011, the linear prediction model of freight volume, the traditional GM(1,1) prediction model, and the improved GM(1, N) prediction model (reference 1) were established. The accuracy of the three models was tested by taking the freight volume data of 2012 and 2013 as reference values. The average relative errors of different models in predicting 2012 and 2013 freight volume are shown in table 3. Through the analysis of table 3, it can be seen that the error between the predicted value and the actual value of the iso-dimensional (7-dimensional) replenished cargo volume prediction model is small, and the prediction accuracy is higher than the other three prediction models.

Table 3 Comparison of average relative errors between 2012 and 2013 of different models

Model	Linear model	GM(1,1) model	Literature[1] model	Iso-dimensional complementary model
Mean relative error	7.68%	6.82%	5.42%	3.66%

5. Conclusion

The research on how to accurately predict the railway freight volume, one of the main basis of engineering technical standards for railway project construction, not only affects the scale of infrastructure project for urban railway construction, but also affects the objective of reasonably formulating a high feasibility railway development strategy to some extent. Based on the research of relevant scholars and the requirements of high-precision prediction method, this paper applies the

gray theory to establish the prediction model of isometric replenishment freight volume, and the main conclusions are as follows:

(1) By improving the traditional GM(1,1) model, the applicability of the improved model in the prediction of freight volume is further verified while the prediction accuracy of the traditional model is improved, which is of high practical significance for extending the application field of GM(1,1) model.

(2) On the basis of improving the traditional model and comparing the accuracy of freight volume prediction model with different dimensions, it can be seen that the accuracy of 7-dimensional prediction model is higher than that of other dimensional models, and the model fitting value is closer to the actual value, which can accurately and timely reflect the change of freight volume.

(3) The accuracy of GM(1,1) freight volume prediction model proposed in this paper is 96.34%, which is higher than that of linear prediction model, traditional GM(1,1) prediction model and improved GM(1, N) prediction model (reference [1]). In addition, this model not only has the advantages of simple calculation and high applicability, but also has high research value and practicability in the research field of freight volume prediction.

References

[1] Song Jianqiang, Bao Xueying, Wang Qicai. A forecast model for freight volume based on improved GM (1, N) model. Journal of Railway Science and Engineering, 2017; 14(1): 180—183.(In Chinese)

[2] Wu Huawen, Zhen Jin, Wang Yu, et al. Study on prediction of railway freight volumes based on RBF neural network. Journal of Railway Science and Engineering, 2014; 11(4): 109—114.(In Chinese)

[3] Tao Hailong. Study on forecast of railway traffic volume based on hybrid intelligent algorithm. Lanzhou: Lanzhou Jiaotong University, 2012.(In Chinese)

[4] Wang Minghui, Zhang Qiao. Study on freight volume prediction of chongqing based on GM(1, 1) model group. Science Technology and Industry, 2012; 12(6): 23—25.(In Chinese)

[5] Zhu Wentong. Forecasting railway freight volume based on improved BP neural network model. Journal of Shijiazhuang Tiedao University, 2014; 27(2):79—82. (In Chinese)

[6] Wang Dong, Mi Guoji. Prediction Study of railway freight volume based on grey relational analysis and BP neural network. Journal of Jiangnan University, 2015; 14(1): 80—84.(In Chinese)