THE APPLICATION OF GREY FORECASTING MODEL BASED ON EXCEL MODELING AND SOLVING IN LOGISTICS DEMAND FORECAST

JIAN-JUN ZHOU

Department of E-commerce and Economics, Sichuan Top IT Vocational Institute, Chengdu 611743, China
E-MAIL: sczhou81@163.com

Abstract:

Logistics demand forecast has an important role to resource optimization and enterprise competitiveness. Grey forecasting model has features such as low sample requirements, high forecast accuracy, it is suitable for forecasting the logistics demand. However, the complexity of the calculation process hindered its promotion and application. This paper briefly introduced the theory of gray model and the processing procedure of GM (1,1) model, then put forward to use the general software Excel to model and solve grey steps forecasting model, further made a detailed description on and methods combined with a case. The analysis of forecast results indicates that this solving method is accurate and efficient.

Keywords: Logistics; demand; forecasting; grey model; Excel

1. Introduction

1.1. The significance of logistics demand forecast

The goal of logistics demand forecast is to accurately grasp the changes of logistics demand, in order to guide the raw material procurement, inventory control, product distribution and other logistics activity. It is necessary to achieve optimal allocation of resources, reduce logistics costs, improve logistics efficiency and promote the balance of logistics supply and demand. Logistics demand forecasting plays an important role in smooth and efficient logistics system. All of the logistics decisions, such as logistics system design and programming, daily order quantity and order time decision etc. should be based on demand forecast. Especially with the rapid development of computer technology, logistics demand forecast technology and capacity has made great progress. The effective use of advanced logistics demand forecast techniques and methods have a significant impact on enterprise's logistics system efficiency, even the enterprise's competitiveness.

1.2. Overview of logistics demand forecasting methods

So far, more than 150 kinds of demand forecast methods have been proposed, these demand forecast methods can be divided into two categories, qualitative forecasting and quantitative forecasting. Thereinto, quantitative forecast methods can be divided into time series forecast method, causality forecast method, and combination forecast method and other categories. Further, the time series forecast methods mainly include arithmetic average, moving average, weighted moving average, exponential smoothing, seasonal variation and gray model. Causality forecast method mainly consists of unary linear regression analysis, multiple linear regression analysis. Combination forecast method is based on two or more single forecast methods; it recalculates a final forecast result according to the weight of single method's result. Combination forecast method will not be discussed in this paper. In a variety of single forecast method, gray forecasting model has several advantages: First, low requirements of sample, distribution regularity of the sample is not need. Furthermore, large number of samples is not necessary; generally four or more samples can be used to figure out a precision-desired result. Second, it can be used in recent, short-term and long-term forecasting. Third, the forecast accuracy is of high level. Due to many advantages, gray system has made considerable progress in the recent thirty years.

2. Gray system and forecasting model

2.1. Overview of grey system theory

The depth of color can be used to describe the clarity of information, black color indicates the information is unknown, white color indicates information is completely clear, gray color indicates part of information is clear, other

is not clear. Accordingly, these systems are called black system, white system, and grey system. Proposed and found by Professor Deng Julong of Huazhong University of Science and Technology, Grey system theory is the only section with Chinese intellectual property in modern management science. Although the system's behavior phenomenon is dim and the data is complex, but still it is ordered, there is a whole function. The study object of grey system is the "poor information" uncertain systems, in which, "partial information is known, other is unknown". Grey system realize, describe and understand the world by generating, developing the partial known information.

2.2. Grey forecasting model

Proposed by Professor Deng Julong, the grey model (GM) is a theory of analysis, modeling, forecasting and controlling for studying grey system that partial information is known, partial information is unknown. thereinto, first-order linear dynamic model GM (1, 1) is a usual gray sequence forecasting model, which is very suitable for logistics demand forecast in case that data is complex and exponential. The processing procedure of GM (1, 1) model can be divided into the following six steps.

(1) Check the feasibility of GM (1, 1) modeling. Judgment criteria is whether original sequence compared ratio (previous data divided by next data) is between $e^{-2/(n+1)}$ and $e^{2/(n+1)}$.

(2) Accumulate the original data to get a new series.

$$x' = x_1' + x_2' + x_3' + \ldots + x_t', \quad x_i' = \sum_{j=1}^{j=i} x_j \tag{1}$$

(3) Construct a matrix.

$$B = \begin{bmatrix} -0.5*(x_1' + x_2') & 1 \\ -0.5*(x_2' + x_3') & 1 \\ \cdots & \cdots \\ -0.5*(x_{t-1}' + x_t') & 1 \end{bmatrix} \tag{2}$$

(4) Construct vectors.

$$Y = (x_2 + x_3 + \ldots + x_t)^T \tag{3}$$

(5) Build GM (1, 1) model.

$$\frac{dx'}{dt} + \alpha x' = \beta \tag{4}$$

(6) Solve to get forecasting model.

$$\hat{x}_{t+1}' = (x_1 - \beta/\alpha)e^{-\alpha} + \beta/\alpha \tag{5}$$

$$\hat{x}_{t+1}' = \hat{x}_{t+1}' - \hat{x}_t' \tag{6}$$

$$\begin{bmatrix} \alpha \\ \beta \end{bmatrix} = (B^T B)^{-1}(B^T Y) \tag{7}$$

As can be seen from above steps, in addition to the raw data to be ready, there are needs for "whitening", and finally comes down to the calculation of coefficients. Including matrix inverse operation, matrix transposition, matrix multiplication, etc., the calculation process is so complex that can't be completed by manual calculations. So, even though the grey model can solve many forecast problems, the complexity of the calculation process hindered its promotion and application. Some dedicated computer softwares are supplied when grey modeling is introduced by experts, but there is some difficult for users to get and to learn. If the calculation process can be completed by mature and general computer software, the efficiency will be greatly improved and it will contribute to the promotion and application of gray model.

3. Excel modeling and solving of grey forecasting model

Excel is an important part of Microsoft Office software suite. It can be widely used in data processing, statistical analyzing and decision supporting in many fields, such as management, statistics, and finance. Especially for the logistics model, Excel has obvious advantages in modeling and data analyzing. By reasonable tabular modeling in Excel, with related functions, the forecasting problems can be easily solved.

3.1 Related functions in Excel modeling and solving of grey forecasting model

3.1.1. TRANSPOSE function

The function TRANSPOSE returns a vertical range of cells as a horizontal range, or vice versa.

Syntax: TRANSPOSE (array)

Array is an array or range of cells on a worksheet that users want to transpose.

3.1.2. MMULT function

The function MMULT returns the matrix product of two arrays. The result is an array with the same number of rows as array1 and the same number of columns as array2.

Syntax: MMULT (array1, array2)

Array1, array2 are the arrays users want to multiply.

3.1.3. MINVERSE function

The function MINVERSE returns the inverse matrix for the matrix stored in an array.

Syntax: MINVERSE (array)

Array is a numeric array with an equal number of rows and columns.

3.2 The detailed process of excel modeling and solving of grey forecasting model

The demand quantity of a certain materials from 2007 to 2012 is known as 26490, 28950,33195,38478,40860 and 45780, now there is a need to calculate the demand of 2013 using grey forecasting model based on the historical data.

3.2.1. Data testing

Create a new worksheet in excel and input the basic data, then input the formula "= D4/D5" in cell J6 and press the Enter key to get the compared ratio for 2007 and 2008. Drag the fill handle downwards to J10 implementing relative references, original sequence compared ratio can be generated. Input the formula "= EXP (-2 / 7)"in cell J4, press the Enter key to get the lower limit of ratio. Input the formula "= 1/J4" in cell J3, press the Enter key to get the upper limit of ratio. Input the formula "IF(AND(MAX(J6:J10)<J3,MIN(J6:J10)>J4)," Tests passed, you can use gray model"," Test failed, you can't use gray model")" in I11. The formula is used to judge automatically whether the grey forecasting model is suitable for the original data sequence. It is shown in figure 1.

	E	F	G	H	I	J
1						
2					2.Data testing	
3	Cumulative sequence	Fitting sequence	Demand forecasted		Upper limits	=1/J4
4	26490	26490	26490		Lower limits	=EXP(-2/7)
5	=D5+E4	=($D$4-$D$32)*EXP(-$D$30*(B5-1))+$D$32	=F5-F4		Test number	
6	=D6+E5	=($D$4-$D$32)*EXP(-$D$30*(B6-1))+$D$32	=F6-F5			=D4/D5
7	=D7+E6	=($D$4-$D$32)*EXP(-$D$30*(B7-1))+$D$32	=F7-F6			=D5/D6
8	=D8+E7	=($D$4-$D$32)*EXP(-$D$30*(B8-1))+$D$32	=F8-F7			=D6/D7
9	=D9+E8	=($D$4-$D$32)*EXP(-$D$30*(B9-1))+$D$32	=F9-F8			=D7/D8
10		=($D$4-$D$32)*EXP(-$D$30*(B10-1))+$D$32	=F10-F9			=D8/D9
11					=IF(AND(MAX(J	

Fig.1 The testing and forecasting formula

3.2.2. Matrix Solution

Input "Matrix B" in cell B13. Input the formula "=-0.5*(E4+E5)" in cell C14 and drag the fill handle to cell C18 ,implementing relative references. Input "1" in cell D14 and drag the fill handle to D18. The region C14: D18 is matrix B.

Input "Matrix B^T" in cell B19. Select the region C20:G21, input the formula "=TRANSPOSE（C14：D18）", press the key combination "Ctrl+Shift+Enter", matrix B^T can be got.

Input "Matrix $B^T * B$" in cell B22. Select the region C23:D24, input the formula "=MMULT(C20:G21，C14：D18)", press the key combination "Ctrl+Shift+Enter", matrix $B^T * B$ can be got.

Input "Matrix $B^T * B^{-1}$" in cell F23. Select the region G23:H24, input the formula "=MINVERSE (C23:D24)", press the key combination "Ctrl+Shift+Enter", matrix $B^T * B^{-1}$ can be got.

Input "Matrix $B^T * B^{-1} * B^T$" in cell B25. Select the region C26:G27, input the formula "=MMULT(G23：H24，C20：G21)", press the key combination "Ctrl+Shift+Enter", matrix $B^T * B^{-1} * B^T$ can be got. The formulas in cells are shown in figure 2. Matrix solution results are shown in fig3.

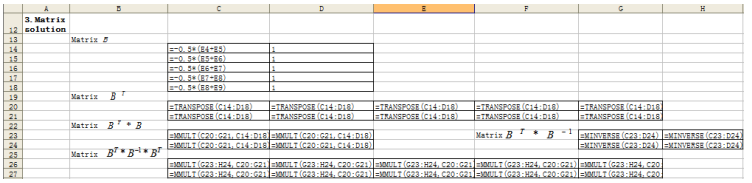

Fig.2 The formula in cells

	A	B	C	D	E	F	G	H
12	3.Matrix solution							
13		Matrix B						
14			-40965	1				
15			-72037.5	1				
16			-107874	1				
17			-147543	1				
18			-190863	1				
19		Matrix B^T						
20			-40965	-72037.5	-107874	-147543	-190863	
21			1	1	1	1	1	
22		Matrix $B^T * B$						
23			767019541 25	-559282.5		Matrix $B^T * B^{-1}$	7.0709E-11	7.909E-06
24			-559282.5	5			7.9092E-06	1.084696
25		Matrix $B^T * B^{-1} * B^T$						
26			5.01263E-06	2.81554E-06	2.81597E-07	-2.52334E-06	-5.586E-06	
27			0.760695434	0.514936649	0.23149841	-0.082251858	-0.4248786	

Fig.3 The matrix solution results

3.2.3. Coefficient solution

Input "Matrix $B^T * B^{-1} * B^T * Y$" in cell B29. Select the region D30:D31, input the formula "=MMULT (C26:G27, D5:D9)", press the key combination "Ctrl+Shift+Enter", matrix $B^T * B^{-1} * B^T * Y$ can be got.

Input "b/a" in cell C32. Input the formula "=D31/D30" in cell D32, press the "Enter" key to get the value of "b/a". It is shown in figure 4.

	A	B	C	D
28	4.Coefficient			
29		Matrix $B^T * B^{-1} * B^T * Y$		
30			a	=MMULT(C26:G27,D5:D9)
31			b	=MMULT(C26:G27,D5:D9)
32			b/a	=D31/D30

Fig.4 The formula for coefficient solution

3.2.4. Data fitting

Input “Fitting sequence” in cell F3 and the value “26490” in cell F4. Input the formula “=($D$4-$D$32)*EXP (-$D$30*(B5-1)) +$D$32” in cell F5, press the “Enter” key to get the fitting sequence value of 2008. Drag the fill handle to F10; we can get the value of year 2008-2013 fitting sequence $\hat{x}_t^{'}$.

Input “Demand Forecasted” in cell G3 and input the value “26490” in cell G4, then input the formula “=F5-F4” in G5,press the “Enter” key to get the forecasted value of 2008, drag the fill handle to cell G10,we can get the forecasted value of 2008-2013.it is shown in figure 5.

	A	B	C	D	E	F	G	H	I	J
2	1. Basic data							2. Data testing		
3		No.	Year	Logistics Demand	Cumulative sequence	Fitting sequence	Demand forecasted		Upper limits	1.3307122
4		1	2007	26490	26490	26490	26490		Lower limits	0.7514773
5		2	2008	28950	55440	56196.13889	29706.1389		Test number	
6		3	2009	33195	88635	89337.80535	33141.6665			0.91503
7		4	2010	38478	127113	126312.3196	36974.5143			0.87212
8		5	2011	40860	167973	167562.9521	41250.6325			0.86270
9		6	2012	45780	213753	213584.2378	46021.2857			0.94170
10		7	2013			264927.9047	51343.6669			0.89253
11								Test passed,model available		

Fig.5 The results of grey forecasting model

3.3 Analysis of forecast result

In above case, grey forecasting model was used to analyze the logistics demand quantity of years 2007-2012. The forecasting value of 2013 was worked out. Compared with the actual logistics demand quantity, the error rate of forecasted data is 3%, 0%,-4%, 1% and 1%, the maximum absolute error value is just 4%. As a single forecast method, the grey forecasting model has a satisfactory accuracy.

4 Conclusion

Using Excel to model and solve gray forecasting model, user need to input the basic data to excel worksheet, design the table appropriately, transform the mathematical model into tabular model associating with Excel functions and formulas, the model can be solved, avoiding the complexity of manual calculations. It can greatly improve the efficiency and accuracy and be useful to the promotion of grey forecasting model in enterprise.

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