Forecast of Second-hand Ship Price Based on Grey Theory

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Abstract

There are many factors could affect the price of second-hand ship, through the regression model is difficult to predict its future trends. Within a long period, the price changes of second-hand ship have a strong regularity, it meets the basic requirements of using GM(1,1) model. The forecast model of second-hand ship based on grey theory is built to simulate the price of second-hand ship tends. It is proved that GM(1,1) model is suitable for forecasting the price tends of second-hand ship with high precision.

Keywords: *second-hand ship; grey forecast; GM(1,1) model*

1. Introduction

With the international shipping market developments and changes in second-hand ship prices, trade of second-hand ship is very active, the purchase of overseas second-hand ships by Chinese enterprises is also very frequent. For any shipping enterprise, ship is its foundation of survival and development. We can even regard the fleet scale as enterprise scale. As a shipping company, ship investment is one of its inevitable economic behaviors. In recent years, with the second-hand ship trading volume gradually increased, trading second-hand vessels gradually increase the proportion in ship trading, second-hand ship purchase decision has become one of the very important problems faced by many shipping companies. However, it is affected by many factors for shipping companies to choose of ordering new ships, or choose to buy second-hand ships, screening of these factors becomes the top priority task of solving ship acquisition decision-making problem. In addition, second-hand ship prices as one of the most important impacting factor in purchase decision-making is always fluctuating, by studying we found that this fluctuation is very regular. Accurately predict the future price fluctuation, and use the predicted results for the second-hand ship purchasing decision-making will greatly improve scientific and operational of the decision-making for shipping companies. It is because building new ships take too long, the cost is too high, usually not been adopted, however, the acquisition of foreign second-hand ships has a lower price, shorter delivery cycle, is adopted by most of the shipping enterprises including SMEs. As the existence of cyclical fluctuations in prices of second-hand ship, in this paper, the gray forecast method is used to predict second-hand ship prices, to tap the market orientation and to avoid price risks for the shipping market operators and investors.

In this article, a detailed analysis of the volatility, wave frequency, period, gradient of price fluctuations has been done to summarize the main fluctuating characters. The characteristics and causes of price fluctuations are systematically organized and analyzed, and build predicting model to forecast second-hand ship prices.

2. Literature Review

As the second-hand ship trading is relatively frequent, assessment of second-hand ship prices and their impact factors are increasingly concerned by the academics all over the world. Michael Beestock and Andress Vergottis (1989) combined the ship idle rate, freight rates, new ship prices, fleet size and price of second-hand ship to build the new model proposed to predict second-hand market for bulk carriers and oil tankers, solved the model dynamic, and achieved good results [1]. DRGlan (1997) used risk analysis model to analysis second-hand ship market [2]. Alizadeh and Nomikos (2003) pointed out that the high rate of return will lead to more trading ships in the market of second-hand bulk ship [3]. Syriopoulos and Roumpis (2006) study shows that the level of freight shipping market will affect the shipping company will purchase the vessel and thus lead a direct impact on second-hand ship price fluctuations. The greater the transaction volume of second-hand ships, ship price and the higher the transparency of related information [4]. Cai li ming and Lu chun xia (2005) took ARIMA model in second-hand ship price forecast, built ARIMA（p, d, q） model through the analysis of time-series data of Panamax second-hand bulk ship prices. The model is used to predict Panamax second-hand bulk ship prices within 2005—2008. According to the analysis of average absolute error, average relative error and root mean square error, metric analysis of the model's forecast performance has gained satisfactory results [5]. Li Jianhua (2008) has in-depth analysis of second-hand ship supply and demand, international dry bulk shipping market demand, the impact of second-hand ship price factors, the evolution of the second-hand ship price index. Then, the calculation method and its historical evolution of the second-hand ship price index are analyzed, more comprehensive description and analysis of the characteristics and the nature of the second-hand ship price index are provided [6]. Zen Bo (2009) used gray predictive modeling to forecast the consumer price index, high accuracy was achieved [7]. Xin Lu (2006) found out that Electricity market price forecast is a changeling yet very important task for electricity market managers and participants. Due to the complexity and uncertainties in the power grid, electricity prices are highly volatile and normally carry with spikes, which may be tens or even hundreds of times higher than the normal price [8]. Tsolakis S. D. (2003) provided an econometric analysis of second-hand ship prices. It starts with a presentation of previous attempts to model second-hand ship prices and their shortcomings. After that a theoretical Error Correction Model is developed making up for these shortcomings. Its results are analysed and compared to those of an atheoretical Autoregressive [9].

In summary, second-hand ship market is an important economic part of the shipping industry, second-hand ship price fluctuations inherent regularity. Currently, most second-hand ship prices forecast are using ARIMA and neural networks. Because the gray prediction method could avoid the forecast deviation caused by lack of relevant data, could avoid the judgmental caused by the impact of personal experience, knowledge and preferences, get better grasp of the system self-evolution, GM (1,1) model is chosen in this second-hand ship price forecasting model and predict based on gray forecasting theory.

3. Wave Theory

According to physical law: “Every action creates an equal and opposite reaction”. The same goes for the financial markets. A price movement up or down must be followed by a contrary movement, as the saying goes: “What goes up must come down” (and vice versa). Price movements can be divided into trends on the one hand and corrections or sideways movements on the other hand. Trends show the main direction of prices, while corrections

move against the trend. In Elliott terminology these are called Impulsive waves and corrective waves [10].

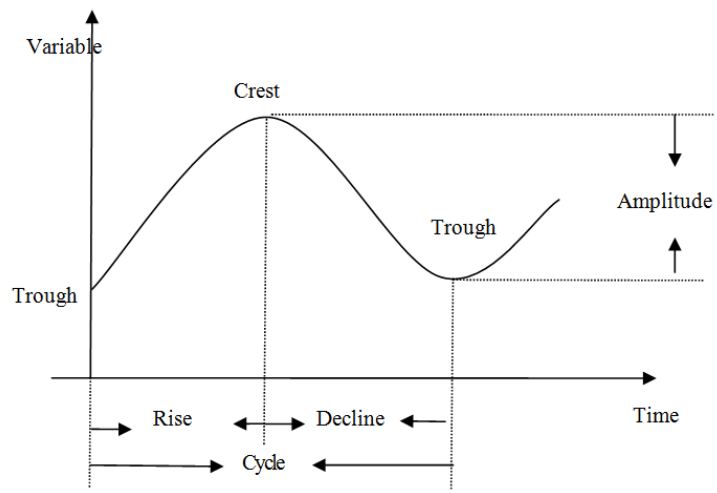

Figure 1. Wave Parameters

(1)Wave duration

When the wave periodic motion is presented, a full-wave time span is called a cycle.

(2) Crest and Trough

Crest is the maximum wave, trough means the minimum value of the wave. The crest values of the different periods are different, a curve composed by a plurality of wave has the maximum crest value and the minimum trough values [11].

(3) Amplitude

Amplitude, also known as volatility, refers to the wave fluctuations deviation. It shows that while wave undulating intensity, amplitude is a measure of the degree of fluctuation of the important indicators. The method of calculating wave amplitude is calculating the crests and troughs of the gap, the maximum amplitude deviation is the maximum wave crest and minimum trough value [12].

$$W_i = Y(P_i) - Y(T_i) \quad (1)$$

W_i represents the amplitude of the wave, $Y(P_i)$ represents the crest of the wave, $Y(T_i)$ represents trough value of wave, subscript i is the time serial number.

(4) Gradient

Fluctuations gradient, is refers to the degree of change in the volatility unit time. Second-hand ship prices may change over time showed stepwise increment or decrement, the gradient reflects the speed of fluctuations increase or decrease. Gradient also somehow reflects the stability of wave [13].

$$H_i = W_i / T_i \quad (2)$$

W_i represents the maximum amplitude within a period, T_i represents the time during changing, subscript i is the time serial number.

Wave trajectory generally is stable, but sometimes abnormal fluctuations of the wave are occurred for special reasons, the specific performance of the crests and troughs or volatility, gradient mutation. It is called a complete fluctuation from one crest to the adjacent another crest, or a trough to another adjacent trough, One complete fluctuation includes two stages and two turning points: the two phases are the rise and fall period; the two turning points are crest and trough.

Changes in the above parameters, represent not only comprehensive description of fluctuations in the current situation of the second-hand ship prices, but also to reflect fluctuations in outliers, which is conducive to the shipping industry and the shipping industry to grasp its fluctuations, thereby improving the scientific accuracy of the decision-making.

4. The impact factors of the second-hand ship price fluctuations

Second-hand ship prices of cyclical fluctuations as an objective laws have gradually been recognized. The object of this paper is a second-hand ship prices, factors that may have an impact on the second-hand ship price fluctuation, and its summarized from the economic, policy, psychological and emergencies.

Table 1. The impact factors of the second-hand ship price fluctuations

impact factors	specific contents
Economic factors	world economic conditions, supply and demand factors
Policy factors	Industry policy, financial policy
Psychological factors	shipowners, shipyards psychological expectations
Emergencies	financial crisis, terrorism, war, strikes, natural disasters

5. GM（1,1） Model

The most commonly way to use the GM model is the first order, one variable differential equation model GM (1, 1), the principle is an accumulated generating raw data sequence (1 - AGO), generated data sequences presented certain laws, construct predictive models. The concrete steps are as follows.

（i） Set the original data as a set of one-dimensional non-negative series $X^{(0)}$,

$$X^{(0)}=(x^{(0)}_{(1)},x^{(0)}_{(2)},\cdots,x^{(0)}_{(n)}),\ x^{(0)}_{(k)}\geq 0,\ k=1,2,\cdots,n. \tag{3}$$

（ii） Construct new series $X^{(1)}$, $X^{(1)}$ is generated from $X^{(0)}$ by time accumulated generating

$$X^{(1)}=(x^{(1)}_{(1)},x^{(1)}_{(2)},\cdots,x^{(1)}_{(n)})=(x^{(0)}_{(1)},x^{(0)}_{(1)}+x^{(0)}_{(2)},\cdots,\sum_{k=1}^{n}x^{(0)}_{(k)}), \tag{4}$$

$$x^{(1)}_{(k)}=\sum_{i=1}^{k}x^{(0)}_{(i)},\ i=1,2,\cdots,k,\ k=1,2,\cdots,n.$$

（iii）Generate $Z^{(1)}$ as close to the mean generator matrix of $X^{(1)}$

$$Z^{(1)}=(z^{(1)}_{(2)},z^{(1)}_{(3)},\cdots,z^{(1)}_{(n)}),\ z^{(1)}_{(k)}=\frac{1}{2}(x^{(1)}_{(k)}+x^{(1)}_{(k-1)}),\ k=1,2,\cdots,n. \quad (5)$$

（iv）Establishment of differential equations,

$$x^{(0)}_{(k)}+az^{(1)}_{(k)}=b. \quad (6)$$

a is the development parameter of the GM (1,1), b is gray endogenous control parameter. This equation is the basic form of the GM (1,1) model.

$$Y=\begin{pmatrix} x_s^{(0)}(2) \\ x_s^{(0)}(3) \\ \vdots \\ x_s^{(0)}(n) \end{pmatrix},B=\begin{pmatrix} -z_s^{(1)}(2) & 1 \\ -z_s^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z_s^{(1)}(n) & 1 \end{pmatrix}. \quad (7)$$

Parameter vector of $x^{(0)}+az^{(1)}=b$ could be captured by the method of least squares, if $\hat{a}=[a,b]^T$, then

$$\hat{a}=[a,b]^T=(B^TB)^{-1}B^TY. \quad (8)$$

（v）Time response sequence of $X^{(0)}(k)+aZ^{(1)}(k)=b$ based on GM(1,1) model is;

$$\hat{X}^{(1)}(k+1)=(X^{(0)}_{(1)}-\frac{b}{a})e^{-ak}+\frac{b}{a}. \quad (9)$$

Restore value is

$$\hat{X}^{(0)}(k+1)=(\hat{X}^{(1)}(k+1)-\hat{X}^{(1)}(k)),\ k=2,3\cdots,n. \quad (10)$$

GM（1,1）model test is commonly includes: residual test, association test and posterior testing.

6. Empirical Analysis AND application

6.1 Second-hand Ship Price Forecasting Model

According to the former description, the 10-year age of 30000dwt dry bulk carriers are used as the research object in this paper. GM（1,1）model is used to set up second-hand ship price forecasting model based on the data from year 1999 to 2004.

Table 2. Data of Second-hand Ship Prices

year	1999	2000	2001	2002	2003	2004
price	8	9	7.75	8.5	10.75	17

（i）Make year 1999 as the starting point, t=1 at this point, the original data sequence is as follow.

$$X^{(0)}=\{x^{(0)}_{(t)}|t=1,2,\cdots,6\}=\{x^{(0)}_{(1)},x^{(0)}_{(2)},\cdots,x^{(0)}_{(6)}\}=\{8, 9, 7.75, 8.5, 10.75, 17\} \quad \textbf{(11)}$$

Figure 2. Second-Hand Ship Price

（ii）Calculate the cumulative series to get $X^{(1)}$:

$$X^{(1)}=\{X^{(1)}_{(t)}|t=1,2,\cdots,6\}=\{8, 17, 24.75, 33.25, 44, 61\} \quad \textbf{(12)}$$

（iii）Calculate $Z^{(1)}$ as the close to the mean generator matrix of $X^{(1)}$

$$Z^{(1)}=\{z^{(1)}_{(2)},\cdots,z^{(1)}_{(6)}\}=\{12.5, 20.875, 29, 38.625, 52.5\} \quad \textbf{(13)}$$

（iv）Calculate the parameters of GM(1,1) model in

$$X^{(0)}(k)+aZ^{(1)}(k)=b\,,\ Y=\begin{pmatrix} x_s^{(0)}(2) \\ x_s^{(0)}(3) \\ \vdots \\ x_s^{(0)}(6) \end{pmatrix}=\begin{pmatrix} 9 \\ 7.75 \\ 8.5 \\ 10.75 \\ 17 \end{pmatrix}, \quad \textbf{(14)}$$

$$B=\begin{pmatrix} -z_s^{(1)}(2) & 1 \\ -z_s^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z_s^{(1)}(n) & 1 \end{pmatrix}=\begin{pmatrix} -12.5 & 1 \\ -20.875 & 1 \\ -29 & 1 \\ -38.625 & 1 \\ -52.5 & 1 \end{pmatrix},$$

$$\hat{a}=[a,b]^T=(B^TB)^{-1}B^TY=\begin{bmatrix} -0.2079 \\ 4.2173 \end{bmatrix}$$

（V）Shadow equation of second-hand ship price based on GM（1,1）model is captured.

$$\frac{dX^{(1)}}{dt}+0.2079X^{(1)}=4.2173 \qquad (15)$$

Time response type of second-hand ship price based on GM（1,1）model is:

$$\hat{X}^{(1)}(k+1)=-20.285+28.285e^{0.2079k},\ k=0,1\cdots,n \qquad (*)$$

6.2 Model Checking

Posterior testing method is used yin this paper. The conclusion is drawn from expression of（*）and（9）: simulation series $\hat{X}^{(0)}$={8, 6.54, 8.05, 9.91, 12.2, 15.01}, residual series $\varepsilon^{(0)}$={0, -2.46, 0.30, 1.41, 1.45, -1.99 }, average of residuals $\bar{\varepsilon}=$-1.29, residual standard deviation S_2=2.13, average of the original data $\bar{X}$=10.17, the standard deviation of the raw data S_1=7.86.

Construct variance ratio statistic C, $C=\frac{S_2}{S_1}$=0.27<0.35（mean square deviation grade I level)，the accuracy of the model is superior.

6.3 Model Application

Using the model to predict the second-hand ship prices of the next six years, the results are captured as follow:

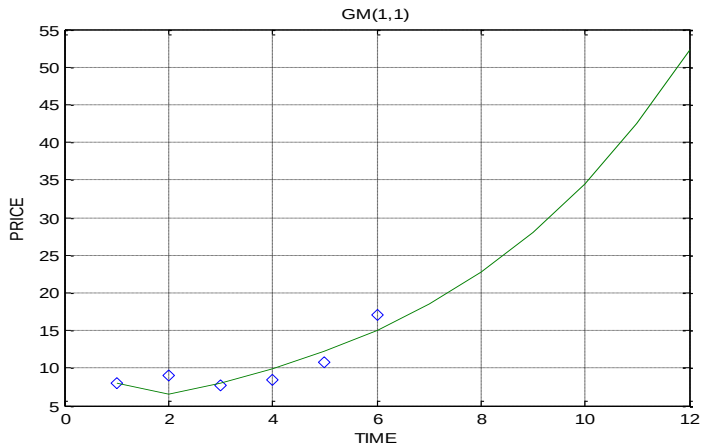

Figure 3. Forecasting of Second-Hand Ship Price

Prediction equation is as:
y =-20.2845+28.2845e^0.20791*(t-1))

Table 3. Results of Forecasting

year	2005	2006	2007	2008	2009	2010
predictive	18.48	22.76	28.02	34.49	42.46	52.27
actual	19	23				

Compare the predicted and actual values of the year 2005 and 2006, make metric analysis of the prediction accuracy of the model through calculating of mean absolute error, mean relative error and root mean square error:

MAE=[(19-18.48)+(23-22.76)]/2=0.38

MPE=[(19-18.48)/19+(23-22.76)/23]/2=0.019

RMSE=$\sqrt{[(19\text{-}18.48)^2+(23\text{-}22.76)^2]/2}=0.405$

Mean absolute error, mean relative error and root mean square error are little enough to tell the high prediction accuracy of the model.

7. Conclusion

The GM(1,1) model which established according to the second-hand ship prices passed relevant inspection, exhibited a high accuracy through analysis of mean absolute error, mean relative error and root mean square error, so this model is suitable of second-hand ship price prediction.

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