Risk forewarning mechanism of ship investment: *model and numerical analysis*

Yuhua Zhu [1], Yujuan Chen [2] *

[1] *College of Transport and Communications, Shanghai Maritime University, No.1550 Haigang Avenue, Pudong New Area, Shanghai 201306, China*

[2] *College of Mathematics and Statistics, Zhejiang University of Finance and Economics, Hangzhou 310018, China*

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Abstract

The ship investment is a capital intensive and high risk industry with a huge amount of investment and long payback period of investment. Therefore, ship owners, shipyards and banks are very concerned about ship prices fluctuation. This paper takes the containership new building prices as an example. The paper analyzes the causes of the containership new building prices fluctuation risk, and analyzes the trend of the containership new building prices by applying the ARIMA model, a classical time series analysis model. Then it establishes the containership new building prices forewarning mechanism model for ship owners, shipyards or banks to control price risk and improve management level.

Keywords: ship investment, containership new building prices, ARIMA model, forewarning mechanism

1 Introduction

Many factors can influence the ship investment. And the ship new building prices are one of the most important factors. In a sharp-changing shipping market, how to grasp the trend of ship new building prices is essential for ship investors. In ship trading market, ship investors reduce costs through the methods of risk management. These methods are mainly based on the company financial situation and capital structure theory. But in practice, these risk management tools are not compatible with shipping capital investors to manage investment risk according to the ship prices fluctuation.

In the early 1980s, Beenstock(1985) [1] has studied the factors which affected the price of ships and he pointed that the traditional theory of supply and demand does not apply to the ship market, because the ship assets have a long period of use. More scholars study the freight market than the ship markets. These papers also can provide some reference for us to study the volatilities of ship prices. Batchelor (2007) used the ARMA model to research and predict the BFI index futures[2]; Yang Weinian (1999) used time series analysis to study the volatility of international Baltic Dry Freight Index (BDI)[3]; Lv Jing and Chen Qinghui(2003) used the ARMA model to study the long-term trend and seasonal fluctuations on the BDI[4]. Zhu Jian (2007) fitted the ARIMA model of BDI[5]; Zhang Ye (2010) used the co-integration theory to study China Container Freight Index[6]. Lin Wenyong, Wang Xiangtao (2006) forecasted the future evolution of the international shipping market[7].Du Zhao-xi, Li Yang, Jin Zhihong(2009) found that Baltic Dry Index has long-term fluctuation variation according to the growth model[8].Zhai Haijie & Li Xuying(2009) used GARCH models to conduct an econometric research on the Baltic Dry Index[9].Wang Lei, Li Xuying(2011) used spectral method to conduct research on monthly data and daily data of BDI[10].Some scholars have analyzed the impact factors of the BDI index fluctuations[11-14].

While seldom any scholars study the containership new building prices trend, and research on forewarning mechanism on the ship investment according to the containership new building prices remains a field rarely touched on.

Containership investment risk forewarning mechanism is based on accurately predicting containership new building prices trends. This paper applies the classic time series analysis model "ARIMA" model to establish the prediction model of containership new building price. And on the basis of the trend of container new building prices, this paper establishes a container ship investment risk forewarning mechanism model to help ship owners, shipyards and financial institutions to grasp the containership new building prices risk variations and occupy a favorable position in the competition in the international shipping market according to the financial enterprise riskyouli forewarning theory.

2 Fluctuation risk of containership new building prices

Containership trade has characteristics of high invest, long cycle and multinational operations. Prices of containership new building prices may be influenced by

* Corresponding author's E-mail: cyjzjhz@sina.com

many factors: not only by the container transport enterprises operating conditions such as operating costs, management level, etc., but also by the world's politics, economy and the impact of international trade as well as other aspects. The key factors affecting the containership new building prices include new building construction costs, second hand ship prices, new ship orders, time charter rate and so on. The combined result of these factors leads to the volatility of container new building prices, and the volatility has brought about a great deal of uncertainties in the income of the containership investors. In addition, due to the cyclical and seasonal changes of international trade, ship trading markets also have the characteristics of cyclical and seasonal volatilities, which cause difficulties to predict the ship new building prices. Because of the high volatilities and uncertainties of container new building prices, ship investors face great business risks. In order to control and prevent risks, it is fundamental to forecast the prices trends accurately and establish a risk forewarning mechanism.

3 Introduction to Time Series Model

Based on the theory of stochastic processes and mathematical-statistical methods, Time series analysis is a statistical method to deal with dynamic data. It solves practical problems by studying statistical regularities of random data. First proposed in the early 1970s by Box and Jenkins[15-17], ARIMA model's full name is Autoregressive Moving Average Model. This method is generally applicable to short-term forecasts, and it reflects three actual variations: trends, cyclical changes and random variations. Commonly used models are: AR model, MA model, ARMA model and ARIMA model. AR model, MA model and the ARMA model are mainly used in the analysis of stationary time series, and the ARIMA model is used in the analysis of non-stationary time series. This paper uses ARIMA model to analyze the trend of the containership average new building prices.

The basic idea of the ARIMA model is to take the forecast object sequence data as a random sequence data, and use ARIMA (p, d, q) model to describe the sequence date approximately. It is structured as follows:

$$\begin{cases}\Phi(L)\Delta^{d}X_t=\Theta(L)\varepsilon_t\\ E(\varepsilon_t)=0,\ \mathrm{Var}(\varepsilon_t)=\delta_\varepsilon^2,\ E(\varepsilon_t,\ \varepsilon_s)=0,\ s\neq t\\ E(x_s,\ \varepsilon_t)=0,\ \forall s<t\end{cases}\qquad(1)$$

In the formula, L is the lag operator; $X_{t-p}=L^pX_t$, $\Delta^d=(1-L)^d$ is d-order difference for the time sequence. $\Phi(L)=1-\phi_1L-\cdots\phi_pL$ is regression coefficients polynomial in the steady and invertible ARMA (p, q) model. p is the autoregressive order. $\Theta(L)=1-\theta_1B-\cdots\theta_qB^q$ is mobile smoothing coefficient polynomial in the steady and invertible ARMA (p, q) model. q is the moving smooth order. ε_t is the white noise sequence.

ARIMA model is a combination of the Differential Operation and ARMA model. A large number of socio-economic data falls into the category of non-stationary time series. Therefore, we should differentiate the data from the appropriate order before using ARIMA model[18-20] and then use the ARIMA model to fit differential steady data. The basic steps of the method are as follows: (1) Definition of the model; (2) Parameter estimation of the model; (3) Inspection and optimization of the model.

(1) Definition of the model. This paper analyzes the randomness, stability, seasonality of the time-series data with autocorrelation and partial autocorrelation analysis method and then determines the type and the order of the model. If the data is not stationary, differentiating data is required. And the next step is to select the appropriate order based on the autocorrelation coefficients (ACF) and the partial autocorrelation coefficient (PACF) of the difference stationary sequence data.

(2) Parameter estimation of model. According to the sample data, this paper uses Ordinary Least Squares method (OLS) to estimate the model: estimate 'p' regression coefficients $\phi_1,\phi_2,\cdots\phi_p$, q moving average coefficients $\theta_1,\theta_2,\cdots\theta_q$.

(3) Inspection and optimization of the model. This paper tests whether each model's residual series is white noise sequence or not. If it is a white noise sequence, the model is feasible. Then it selects the optimal model according to the AIC (Akaike information criterion) or BIC (Bayesian modification of the AIC) indicators in all fitting models.

4 The empirical analysis

4.1 DATA SELECTION AND PROCESSING

This paper selects the containership average new building prices (CNP) from October 1996 to September 2014, a total of 216 data, and uses eviews7.0 software to process the data. Through observation of the raw data, as shown in Figure 1, we can preliminarily pinpoint that the containership average new building prices are non-stationary time series.

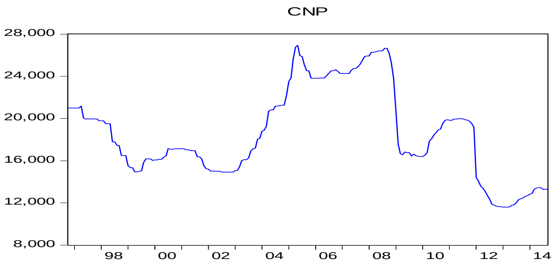

FIGURE 1 The containership average new building prices (CNP) from October 1996 to September 2014

ADF unit root test is performed on the first-order differential sequence data. ADF test results are shown in Table 1. The sequence {CNP} ADF value is greater than the critical value of 1%, so the sequence is a non-stationary series data. The first order difference sequences {dCNP} ADF value is less than the critical value of 1%, so the sequence is a stationary series data. We record it as the process of I(1), then we can model the sequence.

TABLE 1 ADF stationary test results

variable	t-Statistic	Prob.	The critical value of 1% level	The critical value of 5% level	Conclusion
{CNP}	-0.8478	0.3476	-2.5758	-1.9423	**non-stationary**
{dCNP}	**-9.1891**	**0**	**-2.5949**	**-1.9423**	**stationary I（1）**

4.2 PREDICTIVE MODELING

We choose the data from October 1996 to December 2013 to match the ARIMA model, and then predict the containership new building prices from January 2014 to September 2014. Since the {dCNP} sequence is a stationary sequence, this paper uses ARIMA (p,1,q) model to fit {dCNP} sequence data. ‘P’ is the autoregressive order and ‘q’ is the moving average order. They depend on autocorrelation coefficients (ACF) and partial correlation coefficients (PACF) of the sample data. {dCNP} autocorrelation and partial autocorrelation graphics are shown in Figure 2:

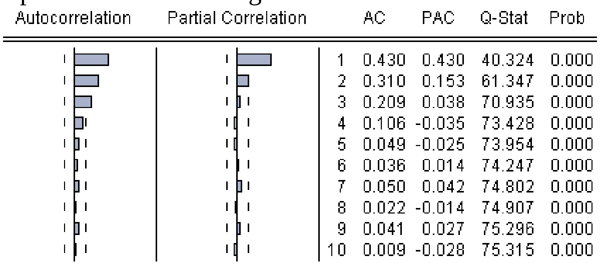

FIGURE 2 {dCNP} autocorrelation and partial autocorrelation graphic

According to the PACF values, the function value obviously rounds towards zero after 3th order. Therefore, ‘p’ is preferable to be ‘3’. According to the ACF value, the values of the 1st and 2nd order significantly are not zero. Therefore ‘q’ can be ‘1’or’2’. Then we can consider the two alternative models: ARIMA(3,1,2), ARIMA(3,1,1). Through eviews7.0 software analysis, we can get AIC values and residual tests of these models. As is shown in Table.2.

TABLE 2 AIC value of the model & the residual test results

Form of models	AIC value	R-squared	residual test results
ARIMA （3,1,2）	15.385	0.254	**pass**
ARIMA （3,1,1）	**15.436**	**0.207**	**pass**

According to Table 2, although these two models all passed the residual test, the AIC value of ARIMA (3,1,2) model is lower than the ARIMA(3,1,1), and the R-square value f ARIMA (3,1,2) model is higher. So we choose ARIMA (3,1,2) model as the predictive model. The model is expressed as:

$$(1-L)(1-0.087L+1.063L^2-0.377L^3)dCNP=(1-0.494L+1.024L^2)\varepsilon_t \ . \quad (2)$$

4.3 FORECAST ANALYSIS OF THE RESULTS

By comparing the forecasted results of ARIMA (3,1,2) model to forecast the containership new building prices from January 2014 to September 2014 with actual prices, it is found that the Theil inequality coefficient of the forecast model is 0.024; deviation and variance proportion is close to zero; and the covariance proportion is 0.03. It proves that the effect of forecast is good. The forecast results are shown in Table 3.

TABLE 3 The comparison of forecast prices (CNPF) and the actual prices (CNP)

month	actual prices($/TEU)	forecast prices($/TEU)	forecast deviation
2014M01	12821.32	12848.91	0.22%
2014M02	12878.78	12783.24	0.74%
2014M03	13285.28	12581.04	5.30%
2014M04	13414.70	12533.77	6.57%
2014M05	13442.47	12682.52	5.65%
2014M06	13442.47	12787.01	4.88%
2014M07	13285.58	12702.71	4.39%
2014M08	13295.26	12573.75	5.43%
2014M09	13295.26	12589.66	5.31%

5 Risk forewarning mechanism based on the analysis of containership new building prices trend

The containership new building prices risk forewarning mechanism is important for ship investor to better control the risk. According to the theory of financial risk management, containership new building prices risk forewarning mechanism is expressed as the five stages, as shown in Figure 3, in this paper: monitoring of the containership new building prices trend, risk identification of the containership new building prices, risk measurement of the containership new building prices, risk discrimination of the containership new building prices, management decisions of the containership new building prices,

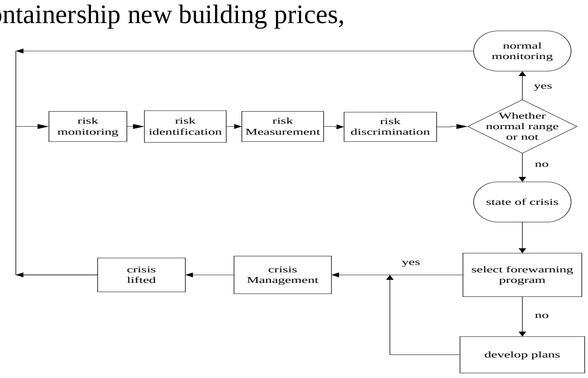

FIGURE 3 The flow chart of the containership new building prices risk forewarning mechanism

Monitoring of the containership new building prices trend is the whole supervision process of the prices changes, and timely identification of the fluctuations. Then this stage provides the basis for identifying the risk of the containership invest. Risk identification of the containership new building prices is the systematic analysis to the potential risk of prices, including tariff risks factors, forms, the degree of influence, nature, and so on. Risk measurement of the containership new building prices is based on the risk identification, including the probability of the prices risks occurred as well as the level of risk. We need to establish the risk of the containership new building prices indicator system.

Risk discrimination of the container shipping freight is based on container freight risk measurement results, including the type and extent of the risk of container freight. We need to determine whether the risk is within acceptable levels in the system. Management decisions of the containership new building prices are based on the result of discrimination. We need to decide whether to monitor the risk of prices or not. If the risks have exceeded the normal range, the investors need to immediately start the crisis management mechanism, and defuse the crisis.

6 Conclusion

The containership new building investment is a high-risk business, and how to reduce the risk has been highly concerned issue for investors. The paper, based on the analysis of time series model of ARIMA model, analyzes the trends of the containership new building prices. The study finds that ARIMA (3,1,2) model can well fit the fluctuations of the containership new building prices, and proposes the risk forewarning mechanism of containership new building invest. It can help ship investors make good use of ship new building prices and reduce business risk.

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Authors

Yuhua Zhu, April 26,1982 ,Zhenjiang, Jiangsu Province,P.R. China
Current position, grades: the lecturer of College of Transport and Communications, Shanghai Maritime University.
University studies: received his B.Sc. in Management of Transport from Shanghai Maritime University in 2000. He received his M.Sc. in Transportation Planning and Management in 2008 as well as Ph.D degree in transport Engineering from Shanghai Maritime University in 2014.
Scientific interest: the shipping finance and management.
Publications: more than 10 papers published in various journals.
Experience: teaching experience of 10 years, has completed four scientific research projects

Yujuan Chen, September 30,1976 ,Zhenjiang, Jiangsu Province,P.R. China

Current position, grades: associate professor
University studies: received the M.Sc. in Accounting from Jiangsu University in 2004, she received her PhD degree in Statistics from Zhejiang Gongshang University.
Scientific interest: Aggregation Operators, Decision Making, Comprehensive evaluation and Uncertainty
Publications: more than 20 papers published in various journals.
Experience: teaching experience of 5 years, has completed more than ten scientific research projects.