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"Maritime Silk Road" Freight Rate Index Forecast Based on ARIMA Model

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Abstract:

Regressive Integrated Moving Average (ARIMA) model was used to accurately understand the changes of shipping prices from China to the Beltand Road countries. Taking the time series of China's "maritime silk road" freight rate index from January 2018 to September 2021 as the training set, the R4.1.2 software was used to carry out the stability analysis, and the ARIMA (0,2,1) model was selected according to the minimum BIC criterion. The mean relative error of forecastwas -12.63, and the absolute error was -5.04%. The model is applied to the price forecast from October to November 2021, and the result shows that the forecastresult of the model is accurate. The ARIMA (0,2,1) model constructed in this paper can provide effective help for China's "the Beltand Road" foreign trade enterprises to timely grasp the law of shipping price changes and make effective decisions.

Keywords:*"The Belt and The Road";Foreign Trade; Shipping Price Index;* Regressive Integrated Moving Average Model

I. INTRODUCTION

Since the strategic concept of "the Beltand Road" was put forward, the cooperation between China and countries along the " the Beltand Road " has become increasingly close. According to China's the Belt and Road Trade and Investment Development Report 2020 released by the Ministry of Commerce of the People's Republic of China, from 2013 to 2019, the total volume of trade in goods between China and countries along the Belt and Road increased from $1.04 trillion to $1.34 trillion.

As one of the important transportation modes for trade between China and countries related to the belt and Road Initiative, shipping volume has been increasing in recent years. The United Nations Conference on Trade and Development expects the volume of international seaborne trade to grow at an average annual rate of 3.4 percent between 2019 and 2024.The Shipping index is a recognized barometer of the shipping market. However, due to the outbreak of COVID-19 around the world in 2020, sea freight rates have been rising and remain high due to unstable supply chains, imbalance between supply and demand in the shipping market, and shipping companies' expectation of recovering losses from the epidemic.

As the domestic epidemic has been effectively controlled and the epidemic is still spreading abroad,

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China's economic recovery is accompanied by a gradual increase in foreign demand for the external market, thus promoting the positive development of China's export market. It can be reasonably predicted that China's shipping volume will remain at a high level soon and will show a rising trend. If the shipping price can be predicted, the cost reduced by enterprises will be considerable.

In the past research results, scholars at home and abroad mainly focused on two aspects, namely, the study of the Maritime Silk Road and the study of China container Freight Index.

First, in terms of the Maritime Silk Road, the research mainly focuses on the evaluation of ports along the route and the impact of China's OFDI. Most scholars often adopt a variety of evaluation methods to comprehensively evaluate the ports along the line.To evaluate the importance of ports along the Maritime Silk Road, Wu et al. innovated the evaluation method of port centrality and proposed a polycentric index, which provided a basis for port management along the Belt and Road[1].Other studies evaluate ports from the perspective of sustainable development. Dong et al. added environmental performance into the evaluation system and found that the operation efficiency of these container ports was higher than their environmental performance, which provided a basis for relevant departments to formulate policies based on local conditions[2].In the research on the impact of China's OFDI, the results of Tian et al. believes that the adjustment of China's industrial structure accelerates Chinese enterprises to go abroad and increase their investment in countries along the Maritime Silk Road[3]. Guo finds that environmental regulations in countries along the Maritime Silk Road have a negative impact on China's OFDI[4].

Secondly, in the study of China container Freight Index, Yin et al. found that under the premise of balance between supply and demand, the seasonal law of container shipping freight is obvious[5]. In the prediction research of specific freight rate index, most scholars adopted a variety of prediction methods. J. W. Jeon et al. used the method of system dynamics to forecast, believing that this method could help users improve the visibility of cash flow and reduce the adverse impact of container shipping fee fluctuations[6].Chen et al. adopted the mixed decomposition integration method of EMD, grey wave and ARMA to help decision-makers make decisions[7]. Meanwhile, W. Xiao et al. predicted China's coastal bulk coal freight price index based on the method of hybrid LSTM integrated learning[8]. SAHIN B et al. used the method of artificial neural network to predict the Baltic Dry bulk freight rate index, and these methods also have certain reference significance for the prediction of China's container freight rate index[9].Z. H. Munim and H. J. Schramm compared artificial neural network and traditional prediction model and believed that ARIMA model had better prediction effect[10]. Existing scholars' research on China's containerized freight rate index is relatively macro, and there are few studies on "Maritime Silk Road" freight rate. "Maritime Silk Road" freight rate is the specific range of shipping freight from China to "the Beltand Road" countries, and it is very meaningful to predict the fluctuation of its freight rate index.

Based on the existing research, ARIMA model is selected to predict the freight rate index of "Maritime Silk Road" in the short term. Once identified, the model can predict future values from past and present values of time series. "Maritime Silk Road" freight rate index is not stable, although it is impossible to

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predict the impact of policy and market unexpected factors on freight rate, but in the period of relatively stable macroeconomic environment, ARIMA model is selected to predict its short-term accuracy is high, with good applicability and reliability.

II. MODELS AND DATA

2.1Models

ARIMA (Autoregressive Integrated Moving Average Model) was a well-known time series prediction method proposed by Box and Jenkins in the early 1970s.Among them, ARIMA (p, d q) is called differential autoregressional moving average model, AR is autoregressional, MA is moving average; P is the autoregressive term, q is the number of moving average terms, and D is the number of differences made when the time series becomes stationary. The basic idea is to treat the data sequence formed by the prediction object over time as a random sequence and use a certain mathematical model to approximate the sequence.

2.2 Data

The "Maritime Silk Road" freight Index, launched by THE Shanghai Hna Exchange in January 2005, comprehensively and timely reflects the maritime trade rates of China and "One Belt and One Road" countries. It plays an important role in the maritime trade field of "One Belt and One Road" and can provide authoritative freight guidance for Chinese "One Belt and One Road" trading enterprises. This study selects "Maritime Silk Road" freight rate index from July 2017 to June 2021 as the data set, as shown in Figure 1. The data source is Shanghai Shipping Exchange, and r-4.1.2 software is used to process the data.

III. ARIMA MODEL CONSTRUCTION OF "MARITIME SILK ROAD" FREIGHT RATE INDEX

3.1 Data stationarity processing

Observed in figure 1, the freight index does not comply with the "maritime silk road", the characteristics of the zero mean and variance can preliminary judgment of the original time series is not stable, at the same time combined with R language unit root test shows the P value is 0.982, is greater than the significance level of 0.05, so can't reject the null hypothesis, the original time series unit root, sequence is smooth.

Due to the non-stationarity of the original time series, differential processing is required for the freight rate index of "Maritime Silk Road". Figure 2 shows the numerical fluctuation of the series after first-order difference and second-order difference. By direct observation of Figure 2, the sequence is still unstable after first-order difference, and close to stationary after second-order difference. In the unit root test, the sequence P value after second-order difference is only 0.01, which is less than the significance level of 0.05. Therefore, the difference order d=1 of ARIMA (P, D, Q) model is determined.

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3.2 Order determination of ARIMA model

First, R was used to draw the autocorrelation and partial autocorrelation analysis diagram of the sequence after second-order difference. As shown in the figure 1, the peak value of the autocorrelation function diagram should be one-step lag and two-step lag, while the peak value of the partial autocorrelation diagram should be two-step lag. Then, the ARIMA(P,2,q) model with p as 2 and Q as 1 floating was further calculated, and the ARIMA model with the least AIC was selected. As shown in the table 1, AIC reaches the minimum value when P =0 and q=1, namely ARIMA (0,2,1).

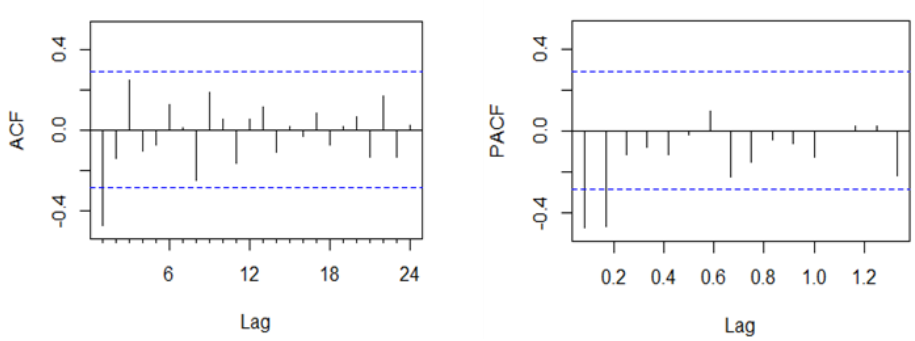

Fig 1: Residual Autocorrelation Function and Partial Autocorrelation Function

TABLE I. AIC

AIC	**q=0**	**q=1**	**q=2**
p=0	347.18	326.45	328.25
p=1	337.1	328.31	330.21
p=2	327.8	328.99	330.58
p=3	329.31	329.76	331.76
p=4	331.06	331.76	-

The table II shows the model accuracy of Model ARIMA (0,2,1). The Root Mean Squared Error (RMSE) is 7.81. MAE (Mean Absolute Error) and MAPE (Mean Absolute Percentage Error) were 5.72 and 5.35% respectively. Although the RMSE and MAPE results of ARIMA (0,2,1) were the worst, MAE results were between ARIMA (2,2,0) and ARIMA (0,2,2), compared with ARIMA (2,2,0) and ARIMA (0,2,2), whose AIC value was 327.8 and 328.25. But not by much. Therefore, ARIMA (0,2,1) model with the lowest AIC is used as the freight rate index time series model of "maritime silk road".

TABLEII. Model Accuracy Test

Training set	**RMSE**	**MAE**	**MAPE**
ARIMA (0,2,1)	7.81	5.72	5.35
ARIMA (2,2,0)	7.76	5.84	5.27

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ARIMA (0,2,2)	7.79	5.66	5.28

3.3 ARIMA model fitting

The forecast package of R language is used to fit ARIMA (0,2,1), and the model results are as follows:

$$x_t = e_t - 0.7691e_{t-1} \quad (1)$$

According to the formula 1, the model includes an error term and a moving average term with a coefficient of -0.7691.

3.4 ARIMA model evaluation of "Maritime Silk Road" Freight rate Index

After completing the construction of ARIMA model of "Maritime Silk Road" freight rate index, the significance of the model was tested.

(1) Normality hypothesis testing

According to the normal Q-Q plot, most of the points in the data fall on the straight line in the graph, and a few dots at both ends are far away from the straight line. Therefore, it can be judged that the data basically meet the normal distribution.

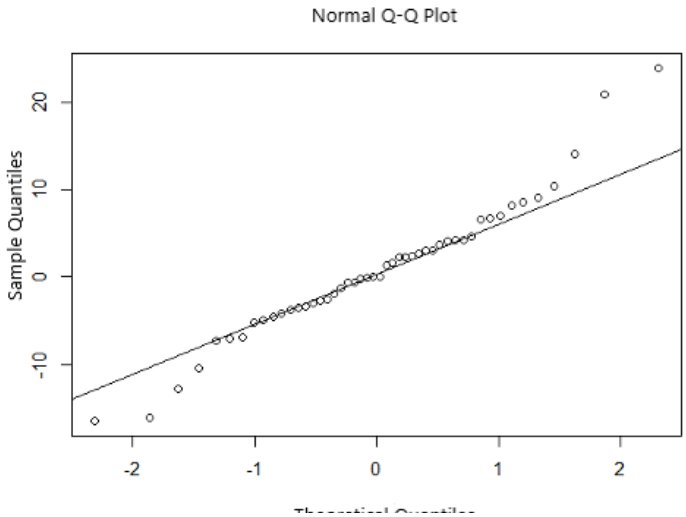

Fig 2: Normal Q-Q Plot

(2) White noise test

The P value is 0.6368, greater than 0.05, and the null hypothesis is accepted. The result is not significant. The autocorrelation coefficient of residual is zero, and the sequence is not correlated, and it is white noise sequence. ARIMA (0,2,1) model can fit this data well.

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IV. ARIMA MODEL PREDICTION RESULTS OF "MARITIME SILK ROAD" FREIGHT RATE INDEX

Through model identification, parameter estimation and model testing, a reasonable prediction model ARIMA (0,2,1) is obtained, which can be used to predict the possible future value of "maritime silk road" freight index. The figure below is the reserved sample prediction result of "maritime silk road" freight rate index from July to September 2021 using ARIMA (0,2,1) model. It can be found that the prediction error of the model increases gradually with time. When predicting the index of the next month, the model shows a good prediction accuracy with a relative error of only -3.54. The absolute error was -1.59 percent, but it increased sharply from the second month. This shows that ARIMA (0,2,1) model has good accuracy in short-term prediction.

TABLEIII. ForecastingErrorResultForArima (0,2,1)

TIME	PREDICTIVEVALUE	THEACTUALVALUE	THERELATIVEERROR	ABSOLUTEERROR	LOW 80	HIGH 80	LOW 95	HIGH 95
JUL-01	219.33	222.87	-3.54	-1.59%	209.00	229.66	203.53	235.13
AUG-01	230.79	247.19	-16.4	-6.63%	214.40	247.17	205.73	255.85
SEP-01	242.24	260.18	-17.94	-6.90%	219.96	264.53	208.16	276.33
AVERAGE	-	-	-12.63	-5.04%	-	-	-	-

V. CONCLUSION

This study aimed to forecast " the Beltand Road " freight rate Index, which can give "Maritime Silk Road" shipper a price reference when they do sea transportation. The main advantages in this study are that we provide an effective andaccuratemethodforshipper to act ahead and avoid most shipping risk while doing foreign trade.The attempted Arima (0,2,1) model achieved good forecasting accuracy aligning with the actual "Maritime Silk Road" freight rate Index, the mean relative error is acceptable.

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