

Research on Price Evaluation of Second-hand Container Ship based on GA-BP Neural Network

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Abstract. As a capital investment, whether the investment in second-hand container ships can bring benefits to the enterprise depends on whether the benefits of ship operation can repay the investment and obtain certain profits. The purchase price of second-hand ships is the key factor, so an evaluation model is built to predict the price of second-hand container ships and evaluate its rationality. To help enterprises better understand the actual price of ships when buying and selling ships, and hope to improve the market evaluation system. In order to accurately evaluate the price of second-hand ships, the Clarkson database was used to obtain 362 container ship transaction data from December 2019 to December 2022, and a GA-BP network neural model based on ship age, deadweight tonnage and new shipbuilding price was established. The weights and thresholds were optimized through genetic algorithms, and then assigned to the BP neural model. The test results show that the mean square error is 0.0185, the evaluation error is basically 20%, and the error within 10% accounts for nearly half. It is proved that the model can preliminarily evaluate the transaction price of second-hand ships, and has certain feasibility and rationality.

Keywords: Second-hand Container Ship Price; BP Neural Network Model; Genetic Algorithm.

1. Introduction

The second-hand ship market, also known as the ship trading market, is one of the main markets in the international shipping market. Its activity is closely related to the shipping market and shipping economy. When the shipping market is good, considering the time lag of shipbuilding and the change of demand, shipping companies buy more second-hand ships to put into the market to increase transport capacity. Compared with building new ships, buying second-hand ships has lower investment costs and can quickly obtain transport capacity. In recent years, affected by the epidemic situation and various emergencies, the second-hand ship market in the container shipping market has become more and more active. Due to the huge funds for shipping investment, the reasonable evaluation of second-hand ship prices affects the subsequent management of daily operating costs and capital costs of shipping enterprises, and affects whether shipping enterprises can survive in the shipping market.

As a big shipping country, China's shipping companies hope to buy and sell ships at the right time to change the size of the fleet, to adapt to the changes in the shipping market, and to seek rapid returns. Whether the investment behavior of the shipping enterprise will bring economic benefits to the enterprise, whether the shipping enterprise can grasp the opportunity of container ship investment and reasonably predict the second-hand container ship price is the key, which requires scientific calculation to predict the second-hand ship price and determine a reasonable purchase price to ensure economic benefits. The transaction price of second-hand container ships will even exceed the price of new ships of the same tonnage in special periods, which has obvious price advantages. Therefore, it is of practical significance for shipping enterprises to correctly evaluate the price of second-hand ships and grasp the opportunity to purchase them:

It plays an important role for shipping enterprises to avoid risks and improve the profitability of enterprises and improve the scientificity of decision-making by assisting enterprises to make decisions and seize the opportunity to purchase ships. Compared with the new shipbuilding market, the second-hand ship market responds more timely to the changes in the world economy. The fluctuation of second-hand ship prices can objectively and timely reflect the changes in the shipping

industry. All shipping companies hope to buy and sell second-hand ships on the premise of fully understanding second-hand ships. By comparing the predicted second-hand container ship prices with the new shipbuilding prices, it provides reference for shipping enterprises to make decisions.

Scholars have done a lot of research on the evaluation of second-hand ship prices. Jiang Zongchuan[1] mainly analyzes three evaluation methods of cost method, market method and income method, as well as the applicable ship types. Zhang Renyi[2] uses Stochastic simulation method to calculate the impact of operation and economic parameters as random variables on the price of second-hand ships. The overall economic benefits of the later life of second-hand ships are analyzed through the dynamic economic indicators of net present value and average annual profit. Li Enlin[3] proposes a purchase decision model based on price fluctuation. First, time series analysis is used to effectively predict the price fluctuation of second-hand ships, and then comprehensive fuzzy evaluation technology is used to evaluate the purchase decision of second-hand ships. Jeroen Frederik Josef[4] based on the time series model, they use GARCH and other methods to find the relationship between second-hand ship prices and factors affecting second-hand ship prices. Ding wavelet[5] uses the fuzzy comprehensive evaluation method to determine the parameter newness rate of the cost method, and the Monte Carlo simulation method to determine the parameter net income of the income present value method. Finally, the applicable evaluation method is selected according to the market characteristics. Duke[6], Luo Fucui[7], Zhang Shufan[8], Li Jianhua[9] establish the BP neural network model, based on the influencing factors of second-hand ship prices. However, there are the following problems: BP neural network is easy to fall into the local optimum, and the global search ability is poor, which affects the evaluation results of the model.

Based on the analysis of the different evaluation methods of the price of second-hand container ships by predecessors and the correlation analysis of the price of second-hand container ships and the influencing factors on the price of second-hand container ships, a BP neural network model optimized by genetic algorithm including ship age, DWT and new ship price is established. This model can not only reduce the impact of subjective factors, It can also use the genetic algorithm with strong global search ability to optimize the BP neural network model and quantitatively evaluate the price of second-hand container ships.

2. The Current Situation of Second hand Container Ship Trading Market and the Evaluation Method of Ship Price

Second hand ships are characterized by fast adaptation to the market and low investment costs. The second-hand container ship market, as the relevant market of the container shipping market, is closely related to the fluctuations of the two, and is a barometer of the changes in the shipping market. The supply and demand changes in the second-hand container ship market affect the supply and demand fundamentals in the container market, and then affect the freight rates in the container shipping market; At the same time, the price changes of second-hand container ships reflect the impact of the container shipping market on the second-hand container ship market. Therefore, first of all, it analyzes the second-hand container ship trading market, and then studies the influencing factors of second-hand container ship prices.

2.1 Analysis on the Current Situation of Second hand Container Ship Trading Market

When the ship owner needs funds, he will choose to sell the ship to obtain funds, or buy the ship when the market is prosperous to obtain high income. According to Clarkson's data, small and medium-sized ships in the second-hand container ship market will be more popular with buyers from 2020 to 2022, because small ships are more flexible than large ships, and are almost not restricted by ports and routes. Secondly, the number of small ships in the market is more than large ships. Ships of medium age are more popular. In terms of cost, the older the ship is, the lower the capital cost is, but the higher the operating cost is. From the perspective of comprehensive cost, the comprehensive cost of middle-aged ships is lower.

In the spring and summer of 2021, the shipping market will be very good. In the case of sufficient demand and limited increase in container ship capacity, the existing containers can no longer provide too much capacity. There are almost no ships in the charter market. Shipping companies need to buy second-hand ships at a high price to increase the supply of capacity. The price of second-hand container ships has soared, and the second-hand ship market is very active. With the decline of spot freight rates in winter and the end of the Christmas freight season, the number of ships traded in the second-hand ship market began to decline. In the first half of 2022, the trend of 2021 will continue. The second-hand ship trading activity will slow down. In the second half of 2022, the market demand will start to weaken and the supply of transport capacity will increase significantly. The market will start to decline and the trading speed of second-hand ships will gradually slow down. Due to a large number of new shipbuilding orders, a large number of new ships will be delivered in the future, and the market may decline rapidly.

The buyer's demand for second-hand ships in the shipping market is influenced by many factors, including external shipping market factors and internal factors of the enterprise itself, such as the freight rate of the container shipping market, the price level of new shipbuilding, the psychological expectation of the future market and the financial situation of the enterprise. When the shipping market is good, the freight rate is high, and the shipping companies have enough funds, the shipping companies are likely to purchase second-hand ships from the market at low capital costs in order to quickly obtain transportation capacity and seize the market, and the demand for second-hand ships increases at this time; When the shipping market is depressed, the freight rate is low and the enterprise funds are insufficient, the market transport capacity is oversupplied, and the ship owner reduces the investment in the ship transport capacity, will not buy second-hand ships, and the demand for them is reduced.

2.2 Analysis of Factors Influencing the Price of Second Hand Container Ships

The influencing factors of second-hand ships mainly include: ship characteristics, including the country of construction, classification society, ship age, etc.; ship size characteristics, including displacement, gross tonnage, shape width, etc.; ship operation characteristics, including new shipbuilding price, ship demolition price, oil consumption, time charter, etc.

1) The price of new shipbuilding is basically synchronized with the price of second-hand ships. As a substitute for second-hand ships, the price of new ships is strongly related to that of second-hand ships. When the shipping market is good, shipping companies choose to buy second-hand ships in order to quickly input transport capacity to adapt to the market. The demand for second-hand ships increases, so the price of second-hand ships is raised; When there is a downward trend in the shipping market, the demand of shipping enterprises for ships decreases, and the price of second-hand ships begins to fall.

2) Generally, the older the ship is, the greater the impact of second-hand ship prices will be, but the age of the ship will be extended in the boom period of the market.

3) The impact of ship building quality, main dimensions and navigation area on the price of second-hand ships. The higher the ship building quality is, the less the maintenance cost is required in the operation. The operating time of the ship increases to improve profitability, and the higher the ship price is; The size of the ship affects the flexibility of the ship to obtain goods at the port, affects the supply and demand of the ship, and then affects the ship price.

4) Like other assets, ship prices depend on investors' expectations and judgments of market development.

2.3 Determination of Model Samples

For the data of second-hand container ships, this paper collected information including ship name, construction time, transaction time, DWT, buyers and sellers, transaction price, new ship price, etc. A total of 362 transaction information were collected from the Clarkson database in the past three years (December 2019 to December 2022). The collected data were preliminarily screened, and the

data with large differences in transaction prices in the same tonnage class were screened out. Finally, a total of 303 transaction data were obtained.

This paper takes ship age, DWT and newbuilding price as independent variables, in which ship age and DWT reflect the impact of ship characteristics on price, and newbuilding price reflects the impact of external factors on price; The second-hand ship transaction price is used as the dependent variable to model and predict the price, and SPSS software is used to analyze the correlation of the variables. The results are shown in Table 1.

Table 1. Correlation between transaction price and ship age, DWT and new shipbuilding price

		Ship age	DWT	Newbuilding price	Transaction price
Transaction price	relevance	-0.31941	0.632776	0.738032	1
	Significance (double tail)	1.3E-08	2.67E-35	2.33E-53	-

The results of correlation analysis show that the price of second-hand container ships has a significant correlation with ship age, DWT and new shipbuilding prices, and the three independent variables have a certain impact on the price of second-hand ships. The ship age is negatively correlated with the second-hand ship price to a low degree, reflecting that the second-hand ship price has a downward trend with the increasing ship age, reflecting the micro transaction factors; DWT and new shipbuilding prices are positively correlated with second-hand ship prices, indicating that the larger the DWT, the higher the second-hand ship price; The higher the price of new shipbuilding, the higher the price of second-hand ships.

2.4 Comparison of Price Evaluation Methods for Second-hand Container Ships

At present, the valuation methods for second-hand ships mainly include market method, income method and replacement cost method. The market approach considers both the shipping market situation and the technical situation of the ship itself, but it is subjective to determine the evaluation parameters. The income method calculates the value of the ship by converting the income of the ship in the future service life into the limit, but it is difficult to predict the income and operating costs of the ship, and there is subjectivity at the same time. The replacement cost method considers the construction cost and depreciation of ships, but does not consider the impact of changes in market supply and demand on ship prices. At the same time, it is difficult to quantify the depreciation of ships.

The three methods are reasonable to some extent, but cannot avoid the impact of subjective factors. Therefore, the following will use the BP neural network model optimized by genetic algorithm to evaluate the price of second-hand ships based on actual data and analyze the results.

3. Establishment of Neural Network Model based on Genetic Algorithm Optimization

BP neural network has strong nonlinear mapping ability. In order to make its weight value can be adjusted efficiently, genetic algorithm is introduced here. Two methods are combined to improve the efficiency of the model, solve the subjective and "nonlinear" problems, and scientifically evaluate the price of second-hand container ships. This paper builds BP neural network model based on the neural network toolbox in MATLAB2020b.

3.1 BP Network Structure Used Ship Price Evaluation and Prediction Model

1) Data preprocessing

Due to the different dimensions among ship age, DWT and new shipbuilding price indicators, in order to ensure the training efficiency of the model, it is necessary to normalize them. The original data is normalized using the mapminmap function of MATLAB.

2) Establish training model

The BP neural network established in this paper has a three-layer structure. The ship age, DWT and new ship price are taken as the input values, and the second-hand container ship transaction price is taken as the output value. The number of nodes in the input layer of the model is 3, and the number of nodes in the output layer is 1. Take 80% of the collected sample data as training samples and 20% as test samples.

3) Determination of the number of hidden layer nodes

The range of the number of nodes is determined by empirical formula, and then the optimal number of hidden layer nodes is determined by program. The number of hidden layer nodes is (3,12). Calculate the training mean square error of different hidden layer nodes, and finally determine that the number of hidden layer nodes is 8.

4) Determination of transfer function

In the BP neural network established in this paper, second-hand ship price evaluation is a nonlinear problem, so the transfer function of the input layer and the hidden layer is tangent S-type transfer function tansig function, and the transfer function of the hidden layer and the output layer is linear purelin function.

5) Determination of training function

This paper uses the BP algorithm trainbr of Bayesian regularization as the training function to improve the Levenberg Marquardt algorithm, enhance the generalization ability of the network, and improve the over fitting phenomenon of the neural network model to a certain extent.

The number of training steps is 1000, the network learning rate is set to 0.1, and the expected mean square deviation of training is set to 000001.

3.2 Establishment of Neural Network Model Optimized by Genetic Algorithm

Genetic Algorithm (GA) is a global optimization search algorithm based on biological natural selection and genetic theory. BP neural network is slow in learning and easy to fall into local optima. Therefore, genetic algorithm is used to optimize neural network (GA-BP neural network) to better prevent falling into local optima.

1) GA-BP neural network model

(1) Coding mechanism is the basis of genetic algorithm to realize mathematical application quantification. At present, binary coding and real coding are commonly used. Real coding has no coding and decoding process, which can improve the accuracy and operation speed of the solution [10]. Therefore, this paper uses real number coding.

(2) The fitness function is used to evaluate individual quality, and eliminate or retain individuals according to the results. The smaller the sum of squares of errors between the output value and the expected output value of the BP neural network, the better the adaptability.

(3) Basic genetic operations: selection, crossover and variation. This paper uses roulette wheel to select new individuals. The crossover probability is between 0.4~0.9. The crossover operator in this paper adopts two-point crossover, and the crossover probability is set as 0.4. The probability of variation is generally between 0~1. The greater the probability of variation, the more new individuals will be generated, which can better handle more diverse changes. This paper sets the probability of variation as 0.2.

(4) Operating parameters. The larger the population size is, the higher the possibility of finding the global optimum is. However, the calculation amount is correspondingly increased, usually 30~100. This paper determines the population size to be 90 through multiple adjustments. The number of iterations is the number of training times of the model when the algorithm terminates. When the optimal solution is obtained, increasing the number of iterations has little impact on the results. This paper determines that the number of iterations is 300 after multiple adjustments.

(5) GA-BP neural network algorithm [11] As shown in Figure 1:

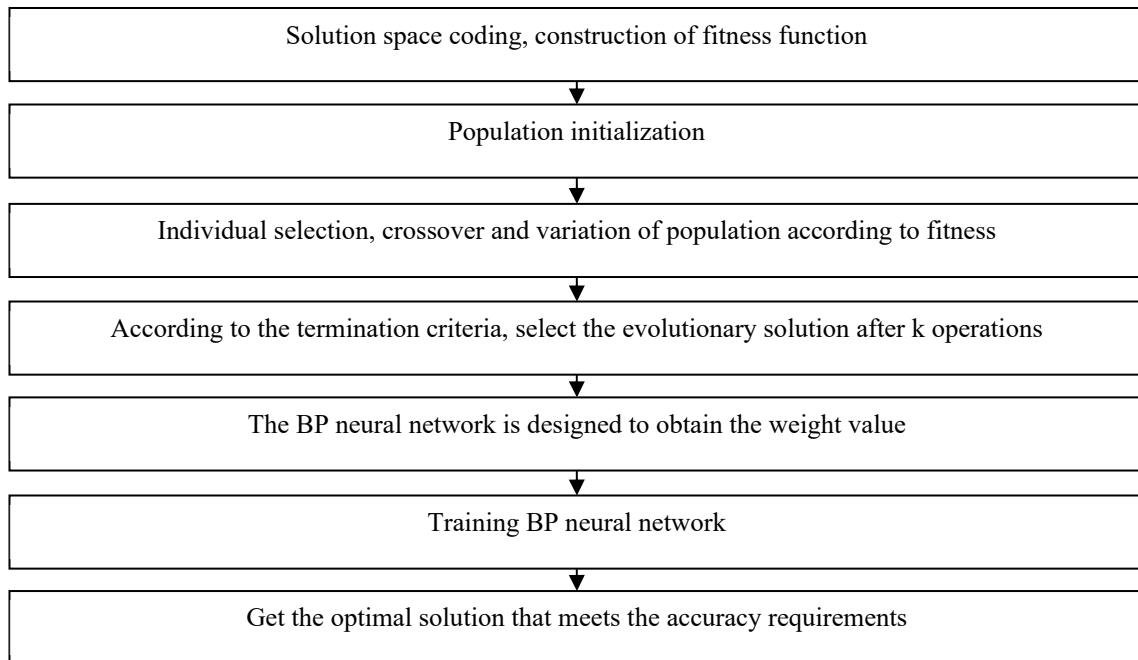


Fig 1. Flow chart of GA-BP neural network model

(6) When using sim function for prediction, the results need to be de normalized, and then compared with the original data.

2) Analysis of model training results

The above operations are implemented in MATLAB. With continuous iterations, the optimal individual test error and population average test error are shrinking, and the best fitness can be found before 300 iterations, which proves that genetic algorithm optimizes the weights of BP neural network and improves the performance of the algorithm.

According to the training results of MATLAB genetic algorithm toolbox, after 375 times of training, the training error can reach the optimal value of 0.0182 after genetic algorithm optimization. According to Figure 2, the model has a good fitting effect in training and testing, and the results show that its correlation is more than 89%, and the evaluation accuracy is high.

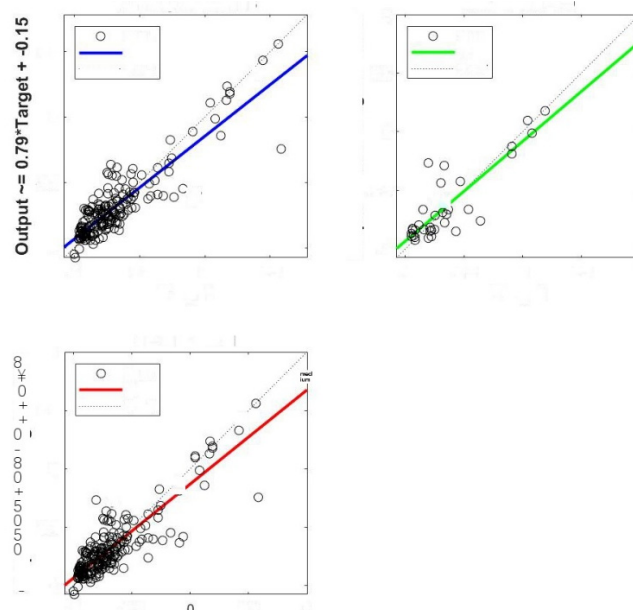


Fig 2. GA-BP Neural Network Training

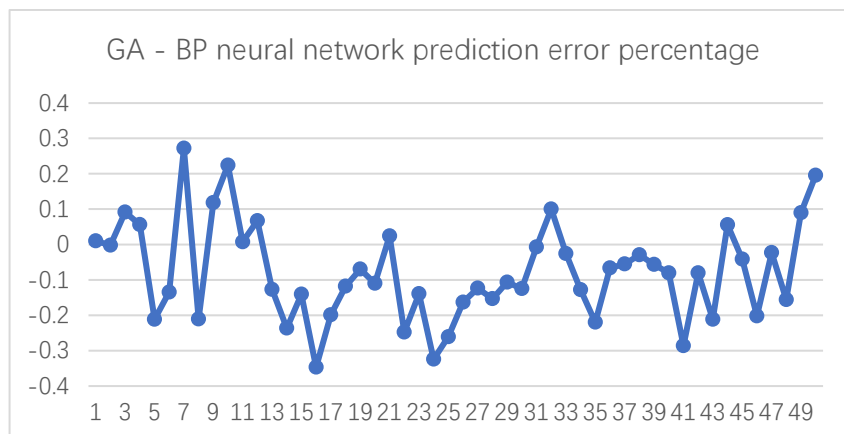


Fig 3. Training error curve

By testing the data, the mean square error of the predicted data is 0.0185, the average absolute error is 0.1093, and the average absolute percentage error is 0.0046. The error ratio is basically kept within 20%, and nearly half is within 10%. It can be concluded that the model established in this paper can accurately evaluate the price of second-hand container ships.

4. Conclusion

This paper analyzes the influence of the container trading market on the price of second-hand containers and the influencing factors of the price of second-hand ships, expounds the important role of the price of second-hand containers in the decision-making of investors, and uses the GA-BP neural network to optimize the weight value and then assign it to the neural network to solve the complex non-linear problem. Based on the factors that affect the price of second-hand ships and the correlation analysis between the price of second-hand ships and different factors, a neural network model optimized by genetic algorithm is established to train the collected transaction data. The error ratio between the simulation prediction results and the actual data is basically within 20%, which indicates that this model can accurately evaluate the price of second-hand container ships.

Although the GA-BP neural network model is reasonable to evaluate the price of second-hand ships, individual data are quite different. Because the second-hand ship transaction is not only affected by the factors of the ship itself and the external environment, but also by the psychology and bargaining power of both parties to the transaction, resulting in a large deviation between the evaluation results and the actual values of some data. Thus a reasonable evaluation and final decision need to consider many aspects.

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