Gray Prediction and Development Analysis of Yingkou PORT's Throughput

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Abstract. With the promotion of global economic integration, the international logistics industry is developing rapidly, and port logistics is booming. As an important part of China's comprehensive transportation and national defense construction, the port is an indispensable infrastructure for economic development, opening to the outside world and trade. Port of Yinkou as "area" strategy in China, the only one in the "zone" and the "road" on the port, is China's domestic manchuria trans-siberian railway transit connect Russia recently, volumes of business's largest port, is also our country away from the nearest port in Russia.

This article mainly USES the SWOT analysis method in strategic management of port of Yinkou established internal conditions to conduct a comprehensive and detailed analysis, combined with the actual and the characteristics of the industry has been clear about the port of Yinkou strengths, weaknesses, challenges and opportunities. At the same time, based on the grey prediction model to predict port of Yinkou port throughput in the next few years port logistics development prospect is promising. At last, some Suggestions about the development of Yingkou port are put forward, and it is hoped to have some reference value for its future port planning.

Keywords: Yingkou port · analysis method · throughput grey prediction

1 Introduction

"Today, with the increasing globalization of economic and trade activities and the growing competition in comprehensive national strength, the international logistics industry is developing rapidly, particularly in the field of port logistics. Ports are an important component of national defense construction, as well as essential infrastructure for national economic development and international trade. Port positioning refers to the determination of the direction of port development, development scale, and functions based on the basic external and internal conditions of the port's location within a certain time and economic hinterland range. Different port positioning leads to different development ideas, strategies, policies, systems, and measures. In addition, in recent years, global economic crises have also affected port and shipping companies. Port throughput is an important part of port development strategy research, and accurate prediction of port throughput is crucial for rational and scientific port layout, investment scale, operation strategies, and comprehensive transportation planning."

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2 Background and Significance of the Study

2.1 The Status and Functions of a Port.

As the saying goes, "a city thrives with its port, and a port serves its city." The development of ports is not only a driving force for the growth of port cities' economies, but also a prerequisite for their development. Port economic development can drive the development of the entire region and even the national economy, and the Yingkou Port has strongly driven the development of the Bohai Economic Rim. Under the strategic pattern of the Maritime Silk Road in the national "Belt and Road" initiative, ports are the most important support points along the Maritime Silk Road, bearing the important mission of linking key areas along the Belt and Road and also carrying out the important task of developing China's foreign trade.

2.2 Relevant Theoretical Framework of the Research

Qualitative prediction methods for port throughput mainly include Delphi method, cargo source survey method, etc., which are suitable for newly built ports that lack historical data and situations where it is difficult to express and solve the complex and variable factors affecting throughput using mathematical methods. Qualitative prediction methods have the characteristics of strong comprehensiveness, requiring less data, simplicity and convenience, but due to the subjectivity of the prediction process and the lack of detailed prediction results, most existing literature focuses on quantitative prediction. Quantitative analysis methods predict future conditions based on historical statistical data through models established using mathematical and statistical methods. Due to its close relationship with statistics, it is also called statistical prediction. According to the different mathematical methods used, the quantitative prediction methods for port throughput can be divided into three categories: time series method, causal analysis method, and combination prediction method. This article focuses on detailed classification and introduction of quantitative prediction methods.

1. Ensemble Forecasting.

In Liu Qiwen et al.'s study [1], taking container throughput data of a certain port as an example, grey theory, triple exponential smoothing, and cubic polynomial prediction models were established. The differences between the predicted fitting values of each model and the actual values of container throughput were compared using MATLAB, and the reasons for the differences and the limitations of single prediction models were analyzed. A combined prediction method for port container throughput was proposed, which was pointed out to reduce prediction errors [1].

Based on historical data of container throughput in Ningbo Port, Cheng Xueping et al. [13] discussed the container throughput using the triple exponential smoothing method, the grey GM(1,1) model, and the combined prediction method. The results showed that the combined prediction model integrated the advantages of the first two prediction methods. Its mean absolute error and mean absolute error of relative values were smaller than those of using only the triple exponential smoothing method or the GM(1,1) model alone, achieving optimal accuracy. Because from the perspective of the entire economic system, any selected variable will be affected by many external factors, which will lead to considerable subjectivity and randomness in the establishment of any single prediction model. This kind of method also faces certain obstacles in practical applications. When several single-item prediction models are combined, the scope of the influencing factors contained will be greatly expanded, which improves the prediction accuracy of the combined prediction model relative to any single prediction model [2].

Grey prediction is a method for predicting systems that contain both known and unknown, non-deterministic information. Although the objects explored by this model are chaotic and seemingly disorderly, they have boundaries and can be considered orderly under specific conditions. In addition, due to the small amount of data on port throughput, it is not possible to use probabilistic statistical methods to find accurate statistical laws, and general prediction methods cannot meet the requirements of prediction accuracy. Therefore, this article selects the grey prediction method to continue predicting the throughput of Yingkou Port.

3 Prediction of the Throughput of Yingkou Port Based on the Grey Prediction Model

3.1 Establishment of the Grey Prediction Model

1. A brief introduction to the Grey Prediction Model.

The Grey Prediction Model is a method used to predict systems that contain both known and unknown, non-deterministic information. Although the objects explored by this model may appear chaotic and disordered, they ultimately have boundaries and can be considered orderly in specific situations.

This paper selects the GM(1,1) model for several reasons. eg: Fig. 1. First, it is a low-order form of the Grey Prediction Model, which has strong applicability and can be well-used for decision-making predictions in various fields. The model requires the initial data to be monotonic and the anticipated trend to be constant and stable. The variation in Yingkou Port's logistics throughput happens to follow a trend of annual growth, with throughput data increasing monotonically, thus meeting the conditions for using the Grey Prediction Model.

Grey Prediction has its own advantages, one of which is that it does not require collecting a large amount of basic data in advance and is an excellent solution for problems with generally small data volumes. Due to the small amount of data on port logistics throughput, it is not possible to use probabilistic statistical methods to find precise statistical regularities, and general forecasting methods cannot meet the requirements for forecasting accuracy. eg: Fig. 2. Therefore, the Grey Prediction Model is selected. The GM(1,1) model of the Grey Prediction Model is used.

2. Developing a framework for predictive analysis.

The Grey Model GM(1,1) used in this paper is a first-order model with one variable. The calculation process for establishing the grey differential equation is as follows:

Given a data series that is equally spaced and monotonic, where x(k) represents the observed value of a quantity at time k, and k represents the time. Let x(k) be the original data sequence. Equations 1.1, 1.2, and 1.3 can be obtained.

(1) $\left\{x^{(n)}\right\} = (1, x1), (2, x2) \cdots (n, x_n)$
(2) $x(0) = \{x10, x20, \cdots xn0\}$
(3) $x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(k) \cdots (k = 1, 2, \cdots, n)$

Since the given original data sequence {x(k)} is a monotonically increasing sequence and x(1)(k) is generated by accumulating once, it has stronger monotonicity. After many accumulations, the randomness of the data sequence will gradually weaken, and the regularity will become more and more obvious. When the number of accumulations is large enough [6], this given sequence can be considered transformed from disorderly to regular. Then, eg: Table 1, by approximating with an exponential curve, a first-order linear constant coefficient differential Eq. 1.4 and an integral curve 1.5 satisfying the initial conditions are obtained, where a and u are undetermined parameters.

(4) $dx(1)/dt + ax(1) = u$
(5) $x(1) = [x(0)(1) - \frac{u}{a}]e - at + \frac{u}{a}$
(6) $dx(1)/dt \approx x(1)(k+1) - x(1)(k)$
(7) $x(0)(k+1) + ax(1)(t) \approx u(k \le t \le k+1)$
(8) $x(0)(k+1) \approx a[-\frac{1}{2}(x(1)(k) + x(1))] + u, \quad (k = 1, 2, \cdots, n)$

$$\begin{pmatrix} a \\ u \end{pmatrix} = (BTB) - 1 \cdot BT \cdot YN$$

(9)
$$\begin{matrix} (-\frac{1}{2}(x^{(1)}(1) + x^{(1)}(2))) & 1 \\ (-\frac{1}{2}(x^{(1)}(2) + x^{(1)}(3))) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(x^{(1)}(n-1) + [x^{(1)}(n)) & 1) \end{matrix} = B, [x^{(0)}(2), x^{(0)}(3), \cdots x^{(0)}(n)] \quad = YN$$

(10) $x^{(1)}(k+1) = [x^{(0)}(1) - \frac{u}{a}]e - ak + \frac{u}{a}$

The final predictive model: GM (1, 1).

3.2 Forecast Analysis of the Total Throughput of a Port

1. Verification of the grey prediction results of the total throughput of port.

(1) Using residuals for accuracy verification, the specific method is as follows [7]:

Calculation based on the predictive model $\hat{x}(1)(k) \quad k = 2, 3, 4$

(2) $x^{(1)}(k) \quad k = 2, 3, 4, 5$

If the predictive model is obtained, it is necessary to restore $\hat{x}^{(1)}(k) \circ \quad \hat{x}^{(1)}(k)$
(11) $\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1)\hat{x}^{(1)}(k)$

(3) Calculation of residuals

(12) $\varepsilon(k) = x^{(0)}(k) - \hat{x}(0)(k)$
Relative error": $\Delta k = |\varepsilon(k)|/x^{(0)}(k)$

If the relative error is below a certain threshold set by the decision maker, the prediction accuracy is considered good. Typically, a threshold of less than 10% is considered to indicate good predictive accuracy."

2. Logistics demand prediction for Yingkou Port based on grey forecasting model.

1. The original data used in this article is the cargo throughput of Yingkou Port from 2011 to 2017, as shown in the figure:

$X(0) = \{1.68, 3.01, 3.3, 3.45, 3.38, 3.52, 3.7\}$

Establish a GM(1,1) model and perform first-order cumulative sum on the original data.:

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

$x^{(1)} = \{x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \cdots, x^{(1)}(n)\} = \{1.68, 4.68, 7.99, 11.44, 14.82, 18.34, 22.04\}$

Calculate the regression curve coefficients B and YN.

$$\begin{pmatrix} -3.18 & 1 \\ -6.335 & 1 \\ -9.715 & 1 \\ -13.13 & 1 \\ -16.58 & 1 \\ -20.19 & 1 \end{pmatrix} = B \quad \begin{pmatrix} 3.01 \\ 3.3 \\ 3.45 \\ 3.38 \\ 3.52 \\ 3.7 \end{pmatrix} = YN.$$

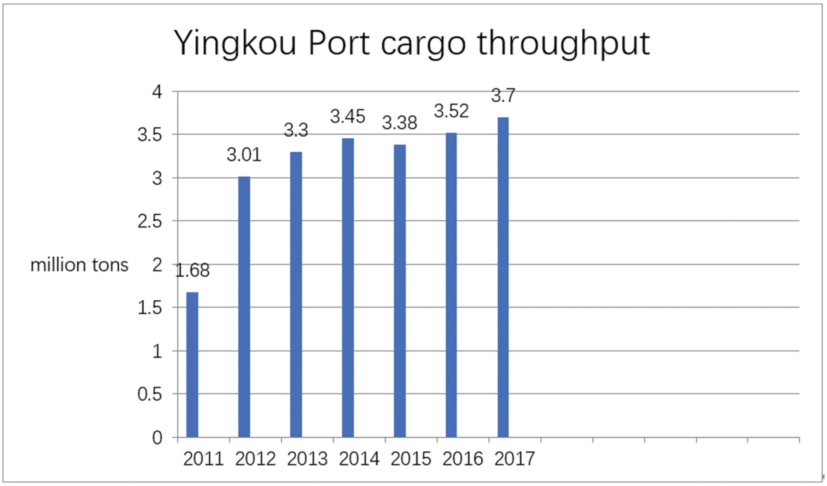

Fig 1. [3] Yingkou Port cargo throughput

Calculate the model parameters using the least squares method $\begin{pmatrix} a \\ u \end{pmatrix} = (B^T B)^{-1} B^T Y_N$

Thus, the obtained differential equation model is: $dx(1)/dt + -0.31x(1) = 2.4$

And because the integrated curve model is: $x^{(1)} = [x^{(0)}(1) - \frac{u}{a}]e - at + \frac{u}{a} = [1.68 + 7.74]e0.31t + 7.74$

$x^{(1)}(k+1) - x^{(1)}(k) = x(0)(k+1)\ (k = 1, 2, \cdots, n)$

2. Prediction results:

3. Extrapolated Prediction by the Model.

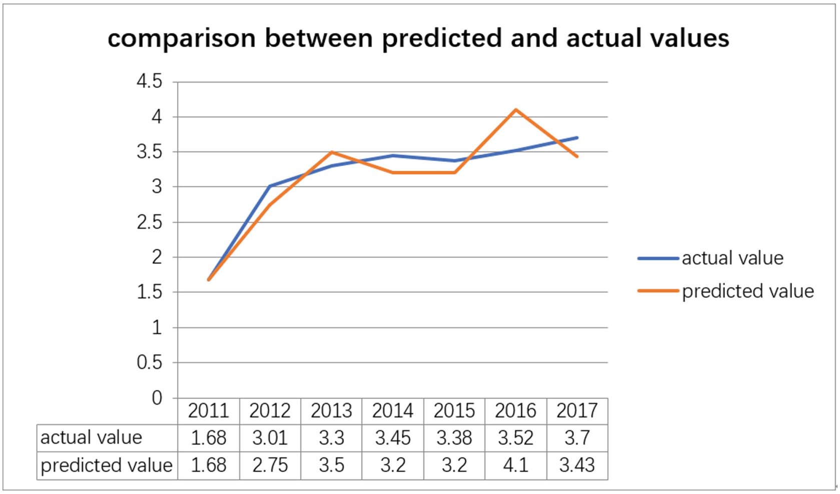

Fig 2. [3] Comparison between predicted and actual values

Table 1. [3] Residual analysis

Residual analysis				
k	$x^{(0)}(k)$	$\hat{x}^{(0)}(k)$	$\varepsilon(k) = x^{(0)}(k) - \hat{x}^{(0)}(k)$	$\Delta_k = \lvert\varepsilon(k)\rvert / x^{(0)}(k)$
2012	2.75	3.01	−0.26	9.4%
2013	3.5	3.3	0.2	5.7%
2014	3.13	3.45	−0.38	7.6%
2015	2.95	3.38	−0.68	8.2%
2016	4.1	3.52	0.58	14%
2017	3.43	3.7	−0.27	8%
mean relative error = 7.6%				

An average error of 7.6% is considered good accuracy if it is less than 10%. After testing, the model can be used for predictions.

Table 2. [3] Predicted throughput for the next five years obtained using the above equation

predicted throughput for the next five years obtained using the above equation					
Year	2018	2019	2020	2021	2022
The predicted value for throughput (hundred million tons)	3.83	4.0	4.17	4.19	5.23

4 The Conclusion of the Throughput Prediction

The conclusion drawn from the analysis using the Grey Forecasting Model in this paper is that the throughput of Yingkou Port is showing a clear upward trend, eg: Table 2, and the logistics development potential of Yingkou Port in the next five years is enormous. The rapid growth of throughput is mainly due to the improvement of necessary conditions for port throughput, such as infrastructure construction [5], such as channel renovation, finished oil and liquid chemical terminal, multi-purpose and container berths, new breakwaters, enclosing walls and revetment engineering [4]. Since the predicted throughput results are simulated based on the development trend in recent years, the trend in the logistics development level of the port in the next few years is not necessarily the actual value that will occur. Therefore, the predicted throughput results can only serve as a reference. Yingkou Port can formulate clear development strategies based on its actual situation, seize the opportunities provided by national policies such as "revitalizing the old industrial base in Northeast China" and "the Belt and Road Initiative," fully utilize its core competitiveness, and give full play to its advantages. Thus, it can overcome various challenges and threats from surrounding ports, move towards the trend of predicted results, and even achieve a new breakthrough in the total throughput of the port.

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