

# Forecast of Container Throughput of Tianjin Port Collection and Distribution System

Zhihong Cui

School of Shanghai Maritime University, Shanghai 201306, China.

1015152991@qq.com

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## Abstract

This paper mainly forecasts the change of container throughput of Tianjin port. In this prediction system, the port throughput data in recent years is known, but the future port throughput data is unknown, and we need to predict it. In fact, this is a typical grey system. According to the grey theory, although the behavior of the system is hazy and the data is complex, it has At the same time, the grey theory establishes the data model, not the original data model, whose data is generated by GM (1, 1) This method is very effective for modeling and analysis of short time series, few statistical data and incomplete information, and can make a long-term fuzzy description of the law of development of things., so GM is adopted (One point one) Through the modeling and calculation of this problem, it is found that in the next five years, the throughput of Tianjin Port presents an overall upward trend, and increases to 2023 year by year one thousand eight hundred and ninety-nine point five four Ten thousand TEU.

## Keywords

Collection and Distribution; Container Throughput; GM (1,1) Model; Modeling.

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## 1. Introduction

Tianjin is an important coastal node of the national "Belt and Road" strategic planning, and the construction of the northern international shipping center is an inevitable measure for Tianjin to actively integrate into this strategy. Responding positively to the national "Belt and Road" strategy and strengthening the active coordination with the construction of "Belt and Road" is the key link to promote the construction of Tianjin North International Shipping Center.

Tianjin Port is the only port in China with four railways leading to Europe's land bridge at the same time. In the larger port cities in China, except Dalian is close to Manzhouli, the distance between Tianjin and Erlianhaote, Alashankou Kashi-) Horgos is all the shortest. At the same time, the index of "international container transit" is particularly important, which is usually used as one of the indicators to measure the international shipping center, so Tianjin Port must increase the proportion of international container transit. In this paper, the future container throughput of Tianjin Port is predicted by modeling and analysis.

## 2. Current Situation and Problems of Collection and Transportation in Tianjin Port

### 2.1 The structure of collecting and distributing transportation system is out of balance and the proportion of railway is low

The transportation mode of Tianjin Port is mainly composed of four kinds: highway, railway, waterway and pipeline, of which 72 are highway ,20 are railway and 8 are waterway and pipeline.

The highway traffic mode dominates, the obvious proportion of railway transportation is on the low side, and the waterway and pipeline transportation need to be further improved.

For a long time, there are problems of "circuitous" and "unobstructed" in the railway collection and distribution channels between Tianjin Port and the interior hinterland. Among the three existing railway collection and distribution channels: the "Northwest Passage" transportation organization is limited by the Beijing Railway Hub and is not closely connected with the Zhang (Jiakou) Hu (he Haote) Bao (head) urban belt; Shenhua Channel is a special coal channel.



Fig. 1 Current Railway Collection and Transportation Channel from Tianjin Port to Midwestern China

At the same time, most of the main ports around Tianjin Port are the main coal export ports, with the rear railway coal transportation channels connected, while Tianjin Port lacks a special line passage to the northwest and central and western regions, which limits the transportation of bulk goods.

## 2.2 The bulk and container distribution structure is also unreasonable

The development of multimodal transport is lagging behind, and sea-rail transport is mainly used in the distribution of bulk goods. The collection and distribution of Tianjin port cargo depends too much on road transportation, which results in the excessive road traffic pressure in the peak period of the port area and reduces the efficiency of the port operation and service.

Railway management system limits the development of railway transportation capacity. At present, there is a separation of ownership and management in railway construction and management in Tianjin Port area. With the gradual development of Tianjin Port, some problems have been exposed in railway construction and maintenance.

First of all, because the ownership of Tianjin Port Railway belongs to the related enterprises in Tianjin Port area, these enterprises have the obligation to pay the related expenses for the construction and maintenance of the railway. However, because the management right belongs to Tianjin Port Railway Management Institute, the separation of ownership and management power will inevitably lead to the difficulty of collecting fees, and the lack of construction and maintenance costs will inevitably lead to the relative delay in the construction and maintenance of the railway. Finally, the railway transportation service capacity and service quality decline. Enterprises have no incentive to bear the related costs, resulting in waste of resources.



Fig. 2 Current situation of coal passage behind Tianjin Port and surrounding ports

**2.3 The highway transportation network is not perfect**

It is urgent to improve the transportation capacity. At present, the regional external transportation network of Tianjin Port is basically perfect. The highway collection and distribution system can reach the scope of Beijing, Tianjin and Hebei at high speed and conveniently, and can play the role of promoting the integration of Beijing, Tianjin and Hebei. However, due to the lack of direct transportation channels, the related transport vehicles need to detour several highways to reach their destination, which takes a lot of time and increases the logistics cost.

In the social distribution structure of Tianjin, the proportion of highway transportation increased to nearly 70, while the proportion of railway transportation was very low, which led to the poor stability of transportation.

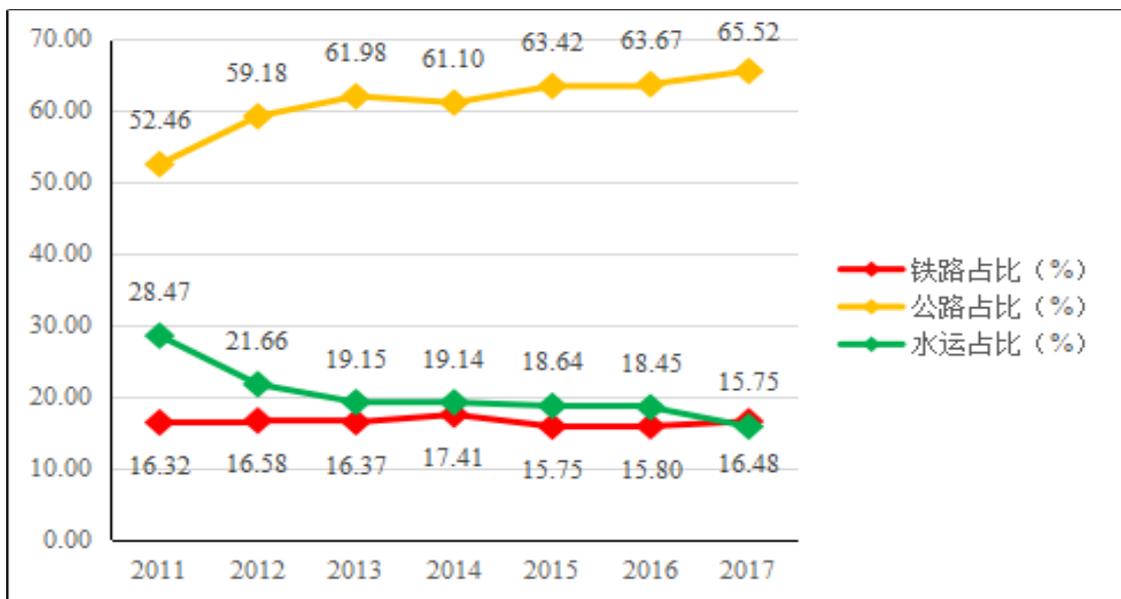


Fig. 3 Structure of Main Mode of Transport of Goods in Tianjin 2011-2017

In addition, the mixed traffic between highway and urban traffic leads to the increasing pressure on urban traffic, highway transportation, land use and environmental protection, and the capacity of many important highway channels is close to or saturated.

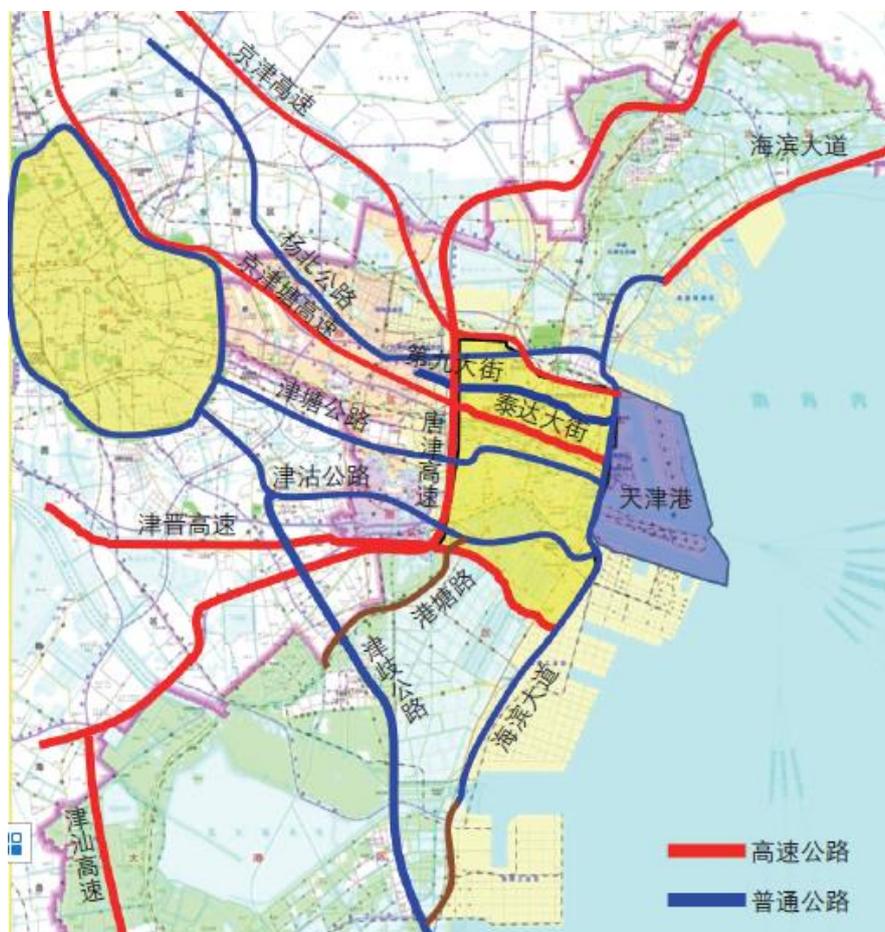


Fig. 4 Current status of Tianjin Port Highway Collection and Distribution Channel

#### 2.4 The conflict between Hong Kong and the city has intensified, which limits the sustainable development of each other in the initial stage of Tianjin Port development

Tianjin Port, Tianjin Economic and technological Development Zone and Free Trade Zone form industry and trade union through "port area linkage", which can develop efficiently and quickly and promote the expansion of Tanggu urban area. With the development and opening of Binhai New area, on the one hand, urban construction limits the port layout of enterprises, on the other hand, the spatial relationship between port and city is more manifested as the interference of port function to the city. The road of Tianjin Port is mainly east-west. On these channels, the traffic of dredging port is mixed with urban traffic, which results in the mixed function of the road, and the capacity of many important collecting and distributing channels is close to or saturated. In addition, with the development of the city, the main railway is gradually in the center of the city, which limits the development of the city, and there are some problems such as low technical the line and insufficient transportation capacity of the passage.

### 3. Prediction model

#### 3.1 Model building

Forecast ——GM(1,1) Model of Container Throughput in Tianjin Port:

Data on container throughput of Tianjin Port in recent years are collected as follows:

Table 1. Three Scheme comparing

Year	2012	2013	2014	2015	2016	2017	2018
Container throughput (10,000 TEU)	1230	1300	1405	1411.13	1450	1507	1601

Step 1: Create a sequence

Establish data time series for cargo throughput:  $X^{(0)}$

$$X^{(0)} = \{X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)\}$$

Sequence ratio sequence  $\sigma$ :

$$\sigma = \{\sigma(2), \sigma(3), \dots, \sigma(n)\}$$

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Grade ratio judgement:

$$\sigma(k) \in (e^{-\frac{2}{n+1}}, e^{\frac{2}{n+1}})$$

This example  $n=7$  because all  $\sigma(k)$  are satisfied:

$$\sigma(k) \in (0.778007831, 1.284025417), k = 2, 3, \dots, 7$$

Therefore, can be used  $X^{(0)}$  for satisfactory GM (1,1) modeling.

Step 2: construct the cumulative sequence, that is, the  $X^{(0)}$  1-AGO sequence

Step 3: To make  $Z^{(1)}$  a  $X^{(1)}$  immediate mean growth sequence, Construct the data matrix  $B$  and data vectors  $Y_n$ .

Step 4: Calculate:

$$\bar{\alpha} = \begin{bmatrix} a \\ b \end{bmatrix}$$

From above  $\bar{\alpha} = \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} -0.036683 \\ 1247.128898 \end{bmatrix}$  and  $-a = 0.036683 < 0.3$  Therefore GM (1,1) model can be used for medium and long term prediction without residual correction.

Step 5: arrive at a prediction model:

$$\text{GM (1,1) prediction models are: } \bar{x}(k + 1) = 35227.46199e^{0.036683k} - 33997.46199$$

Step 6: residual test, calculated as follows:

Table 2. GM (1,1) Model Residual Test Calculation

Serial number $k$	Year	$X^{(0)}$	$\bar{X}^{(0)}$	$\Delta^{(0)}$	$\phi(\%)$	Average $\phi(\%)$
1	2012	1230	1230.00	0	0	
2	2013	1300	1316.24	16.243268	1.2492822	
3	2014	1405	1365.42	39.576455	2.8168295	
4	2015	1411.13	1416.44	5.3114001	0.3763934	1.1656467
5	2016	1450	1469.37	19.365493	1.3355512	
6	2017	1507	1524.27	17.267047	1.1457895	
7	2018	1601	1581.22	19.780049	1.2354809	

As can be seen from the above table, the average relative residual ( $\phi(\%)$ ) is less than 5% and the model has high accuracy.

Step 7: Correlation test:

Table 3. GM (1,1) Calculation table of model association tests

Serial number $k$	Year	$X^{(0)}$	$\bar{X}^{(0)}$	$\Delta^{(0)}$	$\eta$	$\gamma$
1	2012	1230	1230.00	0	1	
2	2013	1300	1316.24	16.243268	0.5491925	
3	2014	1405	1365.42	39.576455	0.3333333	
4	2015	1411.13	1416.44	5.3114001	0.7883873	0.6014906
5	2016	1450	1469.37	19.365493	0.5053984	
6	2017	1507	1524.27	17.267047	0.5340192	
7	2018	1601	1581.22	19.780049	0.5001033	

As can be seen from the table above,  $P = 0.5$  to meet the  $\gamma > 0.6$  inspection criteria.

Step 8: A posteriori test:

Table 4. GM (1,1) Calculation Table for Post-test Difference of Mode

Serial number $k$	Year	$X^{(0)}$	$\Delta^{(0)}$	$\bar{X}^{(0)}$	$S_1$	$\bar{\Delta}$	$S_2$	$C$	$P$
1	2012	1230	0	1414.8757	123.72676	16.791959	12,576333	0.101646	1
2	2013	1300	16.243268						
3	2014	1405	39.576455						
4	2015	1411.13	5.3114001						
5	2016	1450	19.365493	1414.8757	123.72676	16.791959	12,576333	0.101646	1
6	2017	1507	17.267047						
7	2018	1601	19.780049						

The discriminant reference of the posteriori test is as follows:

Table 5. GM (1,1) Discriminant Parameters of Model Post-test Difference

Model Accuracy	Optimal	Qualified	Barely qualified	Unqualified
$P$	$>0.95$	$>0.8$	$>0.7$	$\leq 0.7$
$C$	$<0.35$	$<0.5$	$<0.65$	$\geq 0.65$

As can be seen from the table above, by  $P = 1 > 0.95, C = 0.101646 < 0.5$ . Therefore, the accuracy the above GM (1,1) prediction model is excellent.

Step 9: Projections:

This model predicts the container throughput of Tianjin Port in the next five years, as shown in the following table:

Table 6. Forecast of Container Throughput of Tianjin Port in the Next Five Years

Year	2019	2020	2021	2022	2023
Container throughput (10,000 TEU)	1640.30	1701.59	1765.17	1831.12	1899.54

## 4. Optimal Measures of Tianjin Port Collection and Transportation System Based on Model Prediction Results

### 4.1 Optimization of Port Land Collection and Distribution System

As the hinterland economy grows rapidly, the container throughput of Tianjin Port will continue to rise, and the capacity of highway and railway --as the two most important modes of transportation will also increase greatly. Therefore, the subsystem status of Tianjin Port Highway and Railway can not meet the future needs, so it is urgent to take corresponding measures.

### 4.1.1 Highway

At present, Tianjin highway collection and distribution system is mainly divided into four directions, mainly Beijing-Tianjin channel, northwest channel, northeast channel and southern channel. In order to perfect the highway transportation network, we should build the connecting channel between the four channels as soon as possible, improve the ability of traffic flow conversion on each channel, allocate the traffic flow on each channel reasonably, and improve the transportation capacity and efficiency of the highway transportation network.

The high-speed port network of Tianjin Port is composed of seven horizontal and two vertical highways, which connects the hinterland of the region and undertakes the function of long-distance transportation. The ordinary network of Tianjin Port is composed of seven horizontal and one vertical ordinary roads and urban trunk roads, which plays the role of connecting the surrounding areas of the urban area and serving the short-and medium-distance transportation.



Fig. 5 Planning of Collection and Transportation Channel of Tianjin Port Highway

### 4.1.2 Railways

To improve the railway transportation channel through the hinterland of Tianjin Port, focus on the construction of Tianjin -Baoding -Zhangjiakou -Hohhot -Baotou ,mTianjin -Baoding -Taiyuan Zhongwei/ Yinchuan, Tianjin -Baoding -Taiyuan -Xi'an, three railway container channels, forming the rapid and convenient connection between Tianjin Port and Zhanghubao, and the two main belts, and vigorously developing "sea-rail intermodal transport ".

With the construction of rear railway container passage, consider continuing to promote the layout of "waterless port" to the inland hinterland.

We will speed up the construction of the railway reloading center and further improve the railway-related facilities.

We can use railway special line to improve the efficiency of railway collection and transportation.

Container sea-rail transport subsidies, so that important hinterland cities can compete with the railway freight.



Fig. 6 Planning Port Railway Collection and Distribution Channel Planning

### 4.2 Improved port transit capacity

Tianjin is an important coastal node of the national "Belt and Road" strategic planning, and the construction of the northern international shipping center is an inevitable measure for Tianjin to actively integrate into this strategy. Responding positively to the national "Belt and Road" strategy and strengthening the active coordination with the construction of "Belt and Road" is the key link to promote the construction of Tianjin North International Shipping Center.

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Fig. 7 A New Asia-Europe Mainland Bridge Channel with Tianjin as the Center

#### 4.2.1 Build Tianjin into a "Belt and Road" two-way open bridgehead

The land bridge transportation service of Tianjin port is extended to Europe along the "Silk Road Economic Belt", and four Mainland bridge from Tianjin through Mongolia to Russia and Eastern European countries are opened to realize the efficient connection between the new Asia-Europe Mainland Bridge transportation channel and Tianjin Port.

Tianjin Port will be built into a transit station for trade exchanges between Japan, South Korea and Europe, opening Japan-Tianjin-Europe corridor, promoting the "Silk Road Economic Belt" to the northern coast, and promoting the "21st Century Maritime Silk Road" to extend to the central and western regions. Form a natural logistics corridor running through the east-central-west.

#### 4.2.2 Construction of a feeder transport network around the Bohai Sea

Strengthen the port and shipping alliance, inter-port cooperation, build Tianjin Port as the center of the Bohai Tianjin Port as the center, support the development of other around the Bohai Sea container, so as to increase the water and water transfer ratio of Tianjin Port.

### 4.3 Coordinated development of the Bohai Rim Port Group

At present, we should make full use of the development opportunities of Tianjin's multi-national strategic superposition, take advantage of the unique position of Binhai New Area in the national regional layout, take Tianjin Port as the center and take the main coastal ports of Hebei, Shandong and Liaoning provinces as the sub-center, establish a combined port system with clear division of labor, reasonable planning, perfect function and sound collection and distribution system, so that the market can play a decisive role in the adjustment and distribution of shipping resources in various ports, fully tap the potential of the combined port around the Bohai Sea, and establish a multi-territorial joint coordination leading group to negotiate major port issues, actively share experiences and lessons learned in port management and the development of shipping industry, and realize the realization of each port The coordinated development of the port, give play to the comprehensive benefits of the combined port.

The development of the international shipping center in the north should coordinate the cooperative development relationship between the ports around the Bohai Sea, change the relationship between Tianjin Port and the surrounding ports, strive to achieve dislocation development and complementary advantages, and transform from competition to you and me, to achieve win-win, so that the construction of the Bohai Economic Belt is more orderly.

Tianjin Port should pay attention to excavating and strengthening its own advantages, strengthen docking and cooperation with Tangshan, Huanghua, Qinhuangdao and other ports, gradually reduce the simple loading and unloading of coal, ore and other commodities, and concentrate resources to expand and strengthen the modern logistics industry, international container transport and other business with the free trade zone.

(2) To actively refer to the experience of the Shanghai Composite Port Management Committee, take full account of the actual conditions of the Bohai Rim Port Group, and consider taking the lead by the Ministry of Communications and Transport of the State local transportation authorities of Tianjin, Hebei and Shandong jointly set up the Bohai Rim Composite Port Management Committee to carry out a long-term development plan as a whole.

(3) Drawing on the successful management experience of the Hong Kong Port Shipping Committee, consider setting up a shipping committee of the Northern International Shipping Centre composed of Tianjin Binhai New Area, Tianjin Free Trade Area, Dongjiang Bonded Port Area, Tianjin Binhai International Airport and other relevant parties, and actively organize various related cooperation matters within the region to plan the overall development of the region.

To build the Bohai Rim Rapid Railway, which communicates the Bohai Rim Port Group, and to give full play to the advantages of the Binhai New Area and Tianjin Port in organizing regional logistics and industrial systems efficiently.

#### 4.4 Improve Tianjin Port Container Export Booking Platform

The booking port is to reduce the peak time card arrival by limiting the number of card arrival terminals in different time periods, which is to alleviate the congestion of port roads. An effective method to improve the efficiency of collection and transportation.

According to the shipping and land transportation operation arrangement, each terminal company gives multiple reservation periods and the reservation share of each period through the project platform. The yard applies to the platform for the reservation plan according to its own capacity, and the yard according to the reservation announced by the platform. Reasonable arrangement of their own capacity to collect port operations to avoid road congestion and waiting for air consumption.

#### 5. Conclusion

The GM (1.1) grey forecast model is used to forecast the port throughput. Through our modeling and calculation, we find that the throughput of Tianjin Port shows an upward trend in the next five years, and increases year by year to 18.9954 million TEU in 2023

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