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Grey Correlation Analysis of the Relationship Between Port Logistics and Regional Economic Development in Tangshan City

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Abstract

With the rapid development of the global economy, China has become one of the most important port logistics countries in the world. Port logistics not only promotes the vigorous development of port economy, but also promotes the development of regional economy to a great extent. Taking Tangshan Port as an example, this paper analyzes the correlation between the level of logistics development of Tangshan Port and the level of economic development of Tangshan City. Firstly, we analyze Tangshan Port from two dimensions: the current situation of port logistics development and the current situation of economic development, and secondly, we select relevant data from 2011 to 2020 to conduct a gray correlation analysis between the port throughput of Tangshan Port and various economic indicators of Tangshan City, and analyze the key factors affecting the development of Tangshan Port by calculating their correlation degrees and analyze the research results, based on which provides feasible suggestions for the port logistics development of Tangshan Port. The results show that the tertiary industry has the highest correlation with port logistics, followed by the total investment in fixed assets of the whole society. However, the economic data of total import and export trade has the lowest correlation with the development of port logistics, which indicates that there is a certain incongruity between the development of port logistics and import and export trade. Finally, some suggestions are put forward for the development of Tangshan port logistics, such as optimizing and upgrading the industrial structure, increasing the investment in logistics infrastructure construction, and promoting the coordinated development of import and export trade and port logistics, so as to promote the coordinated development of port logistics and economy.

Keywords: Tangshan Port, port logistics, economic development level, gray correlation analysis

1. Introduction

In April 2022, the People's Government of Hebei Province issued a notice on the development plan of Hebei Province's modern comprehensive transportation system for the 14th Five-Year Plan, which requires the continuous promotion of port transformation and upgrading and resource integration, optimizing of the functional layout of the port, and making Tangshan Port a major hub port for energy and raw materials serving major national strategies, a comprehensive trading port and a bridgehead

for opening up to Northeast Asia. Therefore, the construction of a port-type national hub in Tangshan City should be vigorously promoted, the average annual growth of regional GDP can reach more than 6%. This shows that port logistics has become an indispensable part of the economic construction of the coastal region, and plays an important role in the regional economic development of Tangshan City and the structural upgrading of port-related industries. Therefore, the study of port logistics and regional economic development in Tangshan City has certain practical significance for the economic development of Tangshan City, and has considerable economic value for accelerating the construction of port logistics city and related infrastructure, optimizing international trade and promoting economic development.

As an important coastal port in the southeast of Beijing-Tianjin-Hebei region, Tangshan Port has long been ranked first in Hebei Province in terms of GDP development in the area under its jurisdiction, Tangshan City. The year-on-year growth of Tangshan Port's cargo throughput means that Tangshan Port has taken an important step towards the goal of being a key national development port and a world-class port hub. With the background of location and policy advantages, Tangshan Port and its hinterland welcome the major opportunities of Belt and Road construction and Beijing-Tianjin-Hebei cooperative development strategy. With its superior geographical location and good coastline resources, Tangshan Port provides a constant source of economic vitality for Tangshan City and even for Hebei Province. At present, many scholars have conducted a lot of academic studies on the relationship between port logistics development and regional economy. Some scholars have selected China's major ports for logistics demand forecasting, which is the premise and basis for comprehensive planning of the spatial layout of port logistics and the development direction of port cities. Ding Songbing (Ding Songbing, 2012) takes Shanghai seaport as an example, analyzes the relationship between public influence factors and port logistics demand based on factor analysis, and establishes a logistic growth model to predict the main indicators of port logistics demand. Chen Yan (Chen Yan, Wang Lu & Sun Fengyan, 2017) analyzed the factors influencing the prediction of port logistics demand based on the theory and modeling method of system dynamics from four aspects: economic development of port hinterland, port itself, neighboring ports and relevant external factors, and then played a guiding role in the economic development of port cities. With the deepening of research, some scholars use mathematical models or econometrics to conduct empirical research on the interactive relationship between port logistics and related urban economies. Chenxi Zhao (Zhao Chenxi, Ye Qing & Li Yunfei, 2022) applied the vector autoregressive model to analyze the interaction between port logistics and city economy in Fuzhou based on the port container throughput and GDP of Fuzhou port from 2000 to 2019, and then the conclusion was drawn that there was an interactive relationship between them. Ding Qi (Ding Qi & Li Yunjia, 2022) based on the GDP of Haikou city from 2012 to 2022 and the port container throughput of Haikou during the same period to carry out regression analysis, and puts forward suggestions on developing port logistics to promote the economic growth of Haikou City. By analyzing the related literature, it can be found that the above scholars have made some progress in studying the relationship and development between port logistics and regional economy, but there are few related literature using gray relational powder coat to study Tangshan regional economy and port logistics, and the index selection is different.

This paper analyzes the correlation between the regional economy and the development level of port logistics in Tangshan City based on the sample data from 2011 to 2020, and puts forward relevant development suggestions, which have certain theoretical and practical significance for improving the development level of port logistics in Tangshan and promoting the healthy development of Tangshan regional economy.

2. Port Logistics Development and the Current Situation of the Regional Economy

2.1 Current Situation of Port Logistics Development in Tangshan City

Tangshan Port is located in the Bohai Sea region, including Jingtang Port, Caofeidian Port and Fengnan Port. After nearly 30 years of development and exploration, Tangshan port logistics route can reach more than 190 ports in more than 70 countries and regions in the world, which plays an important role in supporting international trade activities. The main cargoes

of Tangshan Port include coal, steel and metal ores, etc. In recent years, Tangshan Port has actively responded to the call for "One Belt and One Road" construction and carried out multimodal transport services with important provinces in China's "One Generation and One Road" construction, becoming an important port pivot point. Looking at the cargo throughput of the port from 2010 to 2020, the overall trend is increasing year by year. In 2015, there was a significant decline in its cargo throughput, but after that, it began to maintain steady growth. In 2021, the cargo throughput of Tangshan Port was 722.4 million tons, and in terms of cargo throughput of all ports in China this year, the Tangshan Port ranked second, second only to Ningbo Zhoushan Port.

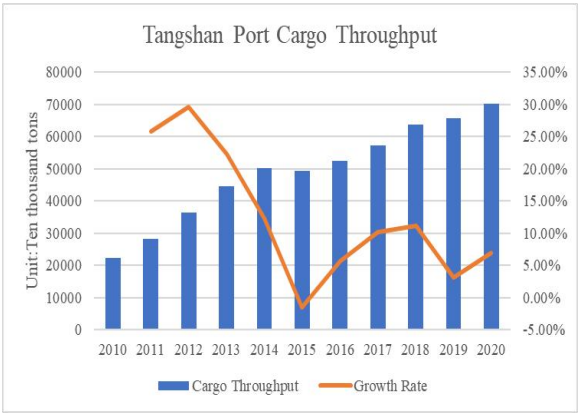

Figure 1. Tangshan Port Cargo Throughput

2.2 Current Situation of Regional Economic Development in Tangshan City

Tangshan City belongs to the center of Bohai Bay, and is adjacent to Beijing and Tianjin, with full sea, land and air transportation, so that it can dock faster to the development needs of Beijing and Tianjin, so as to better ensure the synergistic development of Beijing, Tianjin and Hebei. With the development of economy and society, the economy of Tangshan City has been steadily improving and achieving stable growth. From Figure 2, it can be seen that from 2010 to 2015, the slope gradually became smaller and the growth rate of economic development slowed down, and the total GDP in 2015 was lower than that in 2014. During 2016-2017, there was a new turning point in the economy. It was precise because of the transformation of Tangshan's economic and industrial structure and the vigorous development of the tertiary industry that Tangshan's economic development was on the right track and its economic growth was rapid. From 2019 to 2020, the level of economic development in Tangshan declined, largely due to the outbreak of the epidemic, which made all industries in Tangshan in a state of stagnation. By 2021, Tangshan's regional GDP will reach 823.06 billion yuan, which has achieved steady growth. On the one hand, it comes from the government's macro-control of the current economy, on the other hand, it comes from the new development pattern that the CPC Central Committee has issued that we should fully build a domestic cycle as the main body and give priority to the development of the service industry and promote the development of the tertiary industry.

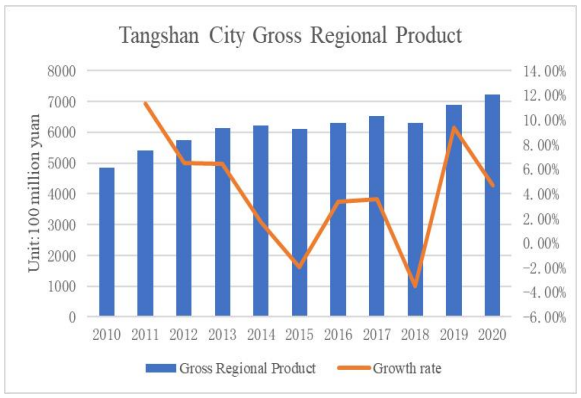

Figure 2. Tangshan City Gross Regional Product

3. Empirical Analysis

3.1 Selection of Indicator Data

This paper will use the grey relational analysis to study the relationship between Tangshan port logistics development and regional economy, and take 2011-2020 as the research interval to study their influence. Considering the index acquisition and the effectiveness of the paper, the specific index system is constructed as follows, based on the index selection basis of scholars in previous literature (Ding Qi & Li Yunjia, 2022; Liu Qingxue et al., 2022; Han Jinghui, 2022). At the economic level, eight indicators are selected: gross regional product (X_1), value added of primary industry (X_2), value added of secondary industry (X_3), value added of tertiary industry (X_4), social fixed asset investment (X_5), total retail sales of social consumer goods (X_6), total import and export volume (X_7) and balance of various RMB deposits in financial institutions (X_8).

Port throughput is an important indicator used to measure port logistics operations, and this

paper uses two indicators, port cargo throughput (X_0) and container cargo throughput (X_0 '), to measure the development level of port logistics. The specific index data are detailed in Table 1.

Table 1. Indicator Data from 2011 to 2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
X_0	24608	31263	36504	50075	49285	52051	57320	63710	65674	70260
X_1	4469.2	5442.5	5861.6	6225.3	6103.1	6306.2	7106.1	6300	6890	7210.9
X_2	421.9	486.5	528.6	558.7	569.1	599	600.7	493.1	531.2	593.4
X_3	2598.4	3269.9	3473.8	3595.75	3365.4	3411.2	4081.4	3319.8	3613.3	3836.7
X_4	1448.9	1686.0	1859.3	2070.85	2168.6	2296	2424	2487	2745.5	2780.7
X_5	2665.8	2545.1	3066.3	4213.17	4619.60	5036.30	5365.30	5687.22	6255.94	6531.20
X_6	1134.5	1334.8	1535.0	1957.11	2138.2	2371.1	2617.2	2743.6	2983.6	2027.6
X_7	939.6	824.8	901.3	1209.4	866.55	705.9	673.7	600	760.5	1021.1
X_8	5324.1	5960.8	6032.4	6766.85	7456.81	8279.86	8748.4	9369.8	10137.98	11180.1

3.2 Calculation and Analysis of the Gray Correlation

In this paper, port cargo throughput and port container throughput are selected to measure the development of port logistics, so two calculations are required in the gray correlation analysis to derive the correlation between port cargo throughput and port container throughput and each economic factor respectively, and finally, the comprehensive correlation coefficient is calculated.

Step 1: The original data are dimensionless by (1) to obtain its initial image.

$$X_i' = \frac{x_i}{x_i(i)} (\text{where} i = 0,1,2,3. \ldots\ldots \text{m}) \quad (1)$$

Table 2. Results of dimensionless processing

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
X_0 '	1.0000	1.2704	1.4834	1.0349	0.9842	1.0395	1.1447	1.2723	1.3115	1.4031
X_1 '	1.0000	1.2178	1.3116	1.3929	0.9804	1.0130	1.1415	1.0120	1.1068	1.1583
X_2 '	1.0000	1.1531	1.2529	1.3242	1.0186	1.0721	1.0752	0.8826	0.9508	1.0621
X_3 '	1.0000	1.2584	1.3369	1.3838	0.9359	0.9487	1.1351	0.9233	1.0049	1.0670
X_4 '	1.0000	1.1636	1.2832	1.4293	1.0472	1.1087	1.1705	1.2010	1.3258	1.3428
X_5 '	1.0000	0.9547	1.1502	1.5805	1.0965	1.1954	1.2735	1.3499	1.4849	1.5502
X_6 '	1.0000	1.1766	1.3530	1.7251	1.0925	1.2115	1.3373	1.4019	1.5245	1.0360
X_7 '	1.0000	0.8778	0.9592	1.2871	0.7165	0.5837	0.5571	0.4961	0.6288	0.8443
X_8 '	1.0000	1.1196	1.1330	1.2710	1.1020	1.2236	1.2928	1.3847	1.4982	1.6522

Step 2: Calculate the absolute difference from (2), and the result is shown in Table 3.

$$\Delta X_i(k) = |X_0'(k) - X_i'(k)|, i = 1,2, \ldots\ldots, m; k \text{ stands for fixed} \quad (2)$$

Table 3. Absolute Difference

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ΔX_1	0.0000	0.0526	0.1718	0.3580	0.0038	0.0265	0.0032	0.2603	0.2047	0.2448
ΔX_2	0.0000	0.1173	0.2305	0.2893	0.0344	0.0326	0.0695	0.3897	0.3607	0.3410

ΔX_3	0.0000	0.0120	0.1465	0.3489	0.0483	0.0908	0.0096	0.3490	0.3066	0.3361
ΔX_4	0.0000	0.1068	0.2002	0.3944	0.0630	0.0692	0.0258	0.0713	0.0143	0.0603
ΔX_5	0.0000	0.3157	0.3322	0.5456	0.1123	0.1559	0.1288	0.0776	0.1734	0.1471
ΔX_6	0.0000	0.0938	0.1304	0.6902	0.1083	0.1720	0.1926	0.1296	0.2130	0.3671
ΔX_7	0.0000	0.3926	0.5242	0.2522	0.2677	0.4558	0.5876	0.7762	0.6827	0.5588
ΔX_8	0.0000	0.1508	0.3504	0.2361	0.1178	0.1841	0.1481	0.1124	0.1867	0.2491

Step 3: Calculate the gray correlation coefficient. According to the results calculated in Table 3, we can see the two polar differences in regional economy in Tangshan City in the past 10 years, the maximum polar difference max=0.7762 and the minimum polar difference min=0. According to the obtained maximum and minimum polar differences, the gray correlation coefficient is calculated by (3), and the correlation coefficient is often taken as 0.5, and the calculation results are shown in Table 4.

$$\varepsilon_{0i}(k) = \frac{min+\rho max}{\Delta X_i(k)+\rho max}, \rho \in (0,1), k = 1,2,\dots\dots,n; i = 1,2,\dots\dots,m \quad (3)$$

Table 4. Gray correlation coefficients

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ε_{01}	1.0000	0.8793	0.6904	0.5169	0.9903	0.9361	0.9918	0.5986	0.6547	0.6132
ε_{02}	1.0000	0.7656	0.6243	0.5698	0.9186	0.9225	0.8481	0.4990	0.5183	0.5323
ε_{03}	1.0000	0.9696	0.7234	0.5234	0.8893	0.8104	0.9759	0.5265	0.5587	0.5359
ε_{04}	1.0000	0.5750	0.6568	0.4927	0.8603	0.8487	0.9377	0.8448	0.9645	0.8655
ε_{05}	1.0000	0.5482	0.5356	0.4125	0.7756	0.7134	0.7508	0.8334	0.6912	0.7251
ε_{06}	1.0000	0.8033	0.7461	0.3569	0.7818	0.6929	0.6683	0.7497	0.6456	0.5139
ε_{07}	1.0000	0.4939	0.4222	0.6030	0.5918	0.4599	0.3978	0.3333	0.3624	0.4099
ε_{08}	1.0000	0.7175	0.5223	0.6187	0.7671	0.6783	0.7238	0.7754	0.6752	0.6091

Step 4: Calculate the gray correlation degree. After calculating the gray correlation analysis degree of the two indicators of port cargo throughput and container cargo throughput respectively, the comprehensive correlation degree is calculated and ranked, and the calculation results are shown in Table 5.

Table 5. Composite correlation table

Indicators	Port cargo throughput (X_0)	Ranking	Container cargo throughput (X_0')	Ranking	Integrated Off Unido	Ranking
Gross regional product (X_1)	0.7861	2	0.5832	5	0.6847	3
Value added of primary industry (X_2)	0.7185	4	0.5743	6	0.6464	7
Value added of secondary industry (X_3)	0.7500	3	0.5698	7	0.6599	4
Value added of tertiary sector (X_4)	0.8038	1	0.6020	4	0.7029	1
Total social fixed asset	0.6971	6	0.6948	1	0.6960	2

investment (X_5)						
Total retail sales of consumer goods (X_6)	0.6942	7	0.6166	3	0.6554	6
Total imports and exports (X_7)	0.5056	8	0.5212	8	0.5134	8
RMB deposits of financial institutions	0.7071	5	0.6119	2	0.6595	5
Balance (X_8)						

This paper analyzes from three perspectives: firstly, from the calculation results of port cargo throughput, the correlation degree of various economic factors is between 0.5056 and 0.8038. The correlation between the added value of tertiary industry and port cargo throughput is 0.8038, and it can be seen from the table that the correlation between the two is the highest, so the added value of tertiary industry has the closest relationship with the development of port logistics. Since the tertiary industry mainly includes services such as transportation, storage and postal services, giving priority to the development of service industry will promote China's domestic circulation and commodity exports and foreign exchange growth as a whole, which in turn can boost the growth of the economy. The correlation between gross regional product and port cargo throughput is 0.7861, ranking second, indicating that the cargo throughput of Tangshan City is closely related to the local economic development and plays an important role in driving the economic construction of Tangshan City.

Secondly, from the analysis of the calculation results of container cargo throughput, the correlation of the economic factors is between 0.5212 and 0.6948. On the whole, the correlation between the economic factors and the development of port logistics represented by the container cargo throughput is low and to a certain extent there is a slight incongruity. However, the correlation between the investment in fixed assets of the whole society and the development level of port logistics can reach 0.6948, which indicates that the infrastructure construction represented by the investment in fixed assets has a promotional effect on the development of port logistics. Because vigorously developing port logistics infrastructure construction can effectively improve the throughput and loading efficiency of port container goods.

Finally, from the overall perspective, Tables 5 show that the correlation between total import and export volume and port logistics are in the last place, which are moderately correlated, and there is a certain development incongruity. Therefore, there is a lot of room for promoting the development of port logistics by the economic factor of total import and export volume.

4. Conclusions and Recommendations

Based on the relevant data of Tangshan City from 2011 to 2020, this paper analyzes the correlation and coordination between the port logistics development level of Tangshan Port and the economic development level of Tangshan City. From the calculation results, the highest correlation is the added value of tertiary industry, followed by the total investment in fixed assets of the whole society. In this regard, it is proposed to optimize the industrial structure, ensure the development of the tertiary industry, promote the development of the primary and secondary industries, and increase the investment in fixed assets, so that Tangshan Port can have more complete logistics facilities and provide better port logistics services. Among them, the correlation coefficient between the total import and export trade and the development of port logistics is the lowest, so it can be used to promote the coordinated development of import and export trade and port logistics in terms of improving the development of port logistics, so as to realize the benign interaction between port development and economy. Therefore, in order to promote the benign interaction between port logistics and hinterland economy of Tangshan Port, this paper puts forward the following suggestions based on the results of empirical analysis.

4.1 Optimize Industrial Structure and Promote the Development of Related Industries

Through the above gray correlation analysis, we

can get that the tertiary industry is the most obvious for the development of port logistics, while the primary industry and the secondary industry have a low correlation with the development level of port logistics. It has the least impact on the development of port logistics. And calculate the growth rates of the added value of the three major industries from 2011 to 2020, which are 5.98%, 6.23% and 26.27% respectively. From this result, the development of the tertiary industry in Tangshan is relatively fast, while the growth rates of the primary industry and the secondary industry are close, both of which are relatively slow. Therefore, we should optimize the industrial structure and give consideration to the optimization and adjustment of the primary industry and the secondary industry while promoting the steady development of the tertiary industry. First of all, we should focus on the development of the secondary industry represented by industry in Tangshan City, and promote the development of port logistics with the development of industry, while paying attention to the efficient development of agriculture, forestry, animal husbandry and fishery.

4.2 Promote the Coordinated Development of Foreign Trade and Port Logistics

From the empirical results, we can get the lowest correlation between total import and export volume and port logistics, the correlation is only 0.5134. Therefore, the import and export trade factors have great room for promoting the economic growth of port logistics. As an important port city in Hebei Province, Tangshan City should make full use of its unique geographical location to promote the development of foreign trade. Port is an important pillar of developing export-oriented economy, we should fully improve the international popularity of Tangshan Port, attract domestic and foreign capital investment, and improve the foreign trade and economic development level of Tangshan City.

4.3 Further Improve the Construction of Logistics Infrastructure

Perfect logistics infrastructure plays an important role in the development of the logistics industry, therefore, it is necessary to increase investment in fixed assets in ports, improve the transportation network, and improve land transportation and port transportation capacity. Increase the construction of logistics parks and build modern comprehensive logistics parks. Finally, it is of great significance to continue to improve the supporting facilities of various docks and stations in the port, improve the degree of mechanization and improve the operational efficiency of port logistics.

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