

Interactive Development of Ningbo-Zhoushan Port and Regional Economy: An Empirical Study Based on VAR Model

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Abstract

This paper takes Ningbo-Zhoushan Port as the research object, adopting the co-integration theory and Granger causality test, adopting the data from 2000 to 2022, selecting the measurement indicators and regional economic indicators of Ningbo-Zhoushan port, to test the relationship between Ningbo-Zhoushan Port and regional economic development. The results show that in a long time, there has been a long-term stable dynamic equilibrium relationship between Ningbo-Zhoushan Port and regional economic development; Ningbo-Zhoushan port has a certain promoting effect on regional economic growth, but the regional economic growth has no significant promoting effect on the development of Ningbo-Zhoushan port. Finally, the paper puts forward some suggestions to promote the good interactive development of Ningbo-Zhoushan port and regional economy.

Keywords

Ningbo-Zhoushan Port, Regional Economy, Interactive Development, VAR Model

1. Introduction

With the development of world economic integration, ports play an increasingly important role in the development of international trade, and the relationship between the development of ports and the development of regional economy is increasingly close. Ningbo-Zhoushan Port is one of the ports with the largest container throughput and cargo throughput in the world, as well as one of the largest cargo distribution and gathering places in China; located in the Yangtze River Delta region, it is the most economically developed region in China and

occupies an important position in the economic and social development of the country. The port is very important to the economic development and the foreign trade of our country. Therefore, the study of the possible interaction between Ningbo-Zhoushan port and regional economy has positive practical significance, and can also provide reference for the economic interaction development of other ports.

In recent years, domestic scholars have done a lot of research on the relationship between ports and regional economic growth by using different methods. (Gripaios & Gripaios, 1995) studied the impact of Plymouth Port on the local economy and found that the port contributed more to the economy of neighboring areas than to the local economy. (Yochum & Agarwal, 1987; Ferrari, Percoco, & Tedeschi, 2010; Bryan, Munday, Pickernell, & Roberts, 2006) found that ports had a significant impact on hinterland economic development. With the upgrading of port energy level and the expansion of radiation range, there will be spill over effect on hinterland cities. (Omiunu, 1989) examined the impact of socioeconomic attributes of seaports on the growth and decline of Warri and Sapele townships in the western Niger Delta region of Nigeria. They used break-point theory (a quantitative technique which utilizes a concept borrowed from the gravity model) the resultant indices show that the socioeconomic effects of the port city of Warri on the four geographically contiguous local government areas—Okpe (Sapele), Ughelli, Ethiope and Warri—are strongest. (Coppens, Lagneaux, Meersman, Sellekaerts, van de Voorde, van Gastel, Vanel-slander, & Verhetsel, 2007) recognizes that there is a highly synergistic coupling relationship between port and regional economy, so it is of great value to further improve the driving role of the port on economy. (Liang & Chen, 2011) analyzed the long-term equilibrium relationships among value added of tertiary industry, total imports, exports and port handling capacity based on the co-integration model, finally researched the systems of the long-term and short-term dynamic effects on tertiary industry and imports and exports with the development of the port. (Woo, 2015) used data from Dalian city in China during 1980-2010, examined the issue of causality between port and economic growth at the urban level, they mainly researched the examination of the role of the seaport and its related variations in economic growth in case of Dalian City. (Wilmsmeier, Monios, & Rodrigue, 2015) found that ports, direct economic hinterlands and port cities are interdependent, interact and develop together. The port has a positive spillover effect on the economic growth of the direct economic hinterland and the port city, the economic development of the port city provides the basic guarantee for the construction and improvement of the port. (Heijman, Gardebroek, & van Os, 2017) pointed out that regional economy has a significant impact on port economy, the formation and development of economy plays a basic role, and the port is an important driving force for the economic development of the hinterland, and the port and the hinterland can form a benign interaction mechanism to promote the common development of both sides. (Wilmsmeier,

Monios, & Rodrigue, 2015) based on the analysis of ports as urban economic system that depict the overall impact of a port on the function mechanism of urban economy. They took Shenzhen Port as an example, cargo handled at the seaports of Shenzhen, gross domestic product of Shenzhen, and the number of employed persons of Shenzhen, respectively, built VAR model and analyzed the two sets of variables based on the impulse response and variance decomposition. (Yang & Kim, 2020) in order to discuss the relevance effect of interaction between the port group and regional economy, they adapted data between 2007-2018 and built up a causal relationship between Ningbo-Zhoushan Port and the corresponding regional economy indicator, they believed that GDP is the most important index influencing port cargo handling capacity, the continuous growth of regional GDP assures the growth of port cargo handling capacity and the regional economic development level has a great influence on the port's high-quality development.

By reviewing the literature, the research on the interactive development of port and regional economy has achieved relevant results both theoretically and empirically. The quantitative research methods mainly include input-output model, econometric method and system dynamics method, etc. However, most of the studies are mainly static analysis, which cannot objectively reflect the dynamic changes of port and regional economy, so it is difficult to fully reflect its evolution law. In addition, some dynamic studies mainly focus on whether there is a co-integration relationship between port and regional economy and how relevant they are, and the conclusions are relatively simple. The paper uses the Granger-Causality Test to analyze the two-way causality between port and regional economy growth in Zhejiang Province, and finds out that they are the cause for each other. Therefore, the correlation analysis of port and regional economic development is very important, in order to provide a theoretical basis for decision makers on the interactive development of port and regional economy.

2. Overview of Ningbo-Zhoushan Port and Hinterland Economy

2.1. Overview of Ningbo-Zhoushan Port

Ningbo-Zhoushan Port is located in the middle of China's mainland coastline, the south wing of the Yangtze River Economic Belt. It is China that opens first-class ports to the outside world. As one of the largest ports in the Yangtze River Delta port group, it is a major port in China's coastal region and an important hub of China's national comprehensive transportation system. Since 2000, the cargo throughput of Ningbo-Zhoushan Port has shown an overall trend of continuous growth (See [Figure 1](#)). The cargo throughput of Ningbo-Zhoushan Port has increased from 115 million tons in 2000 to 1.261 billion tons in 2022, maintaining the world's first place for 14 consecutive years. In 2022, the container throughput of Ningbo-Zhoushan Port reached 33.35 million TEU, ranking third in the world.

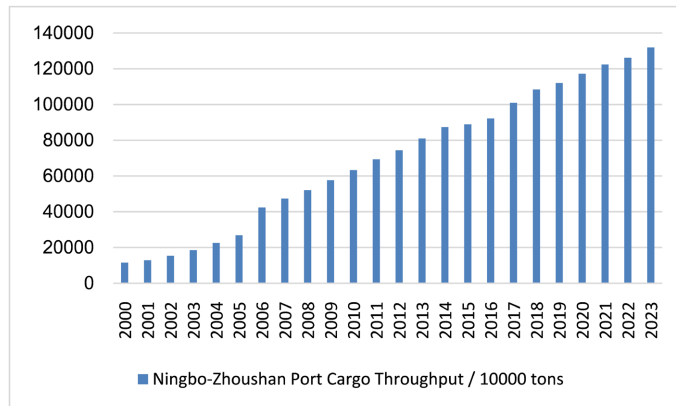


Figure 1. The throughput of Ningbo-Zhoushan Port from 2000 to 2022. Data Source: China Port Yearbook.

2.2. Economic Overview of Hinterland of Ningbo-Zhoushan Port

Port hinterland refers to the area where cargo and passengers are collected and dispersed in the port, and it is also the area where the port economic development can drive and radiate the surrounding economy. The port economic hinterland includes direct hinterland and indirect hinterland. Ningbo-Zhoushan Port has a broad direct economic hinterland due to its superior geographical advantage and economic strength. According to the official website of Ningbo-Zhoushan Port and the research results of predecessors, the direct economic hinterland of Ningbo-Zhoushan Port mainly includes Zhejiang Province (See **Figure 2**). From the perspective of economic aggregate, the GDP of Zhejiang Province in the hinterland of Ningbo-Zhoushan Port has a sustained and rapid growth trend, increasing from 616.479 billion yuan in 2000 to 771.536 billion yuan in 2022, with an average annual growth rate of 12.2%; From the perspective of industrial structure, the secondary industry increased from 328.71 billion yuan to 3320.52 billion yuan, with an average annual growth rate of nearly 11.1%. The industrial structure of Zhejiang Province has been continuously optimized (This section date: Zhejiang Statistics Yearbook).



Figure 2. The hinterland economic of Ningbo-Zhoushan Port.

2.3. Index Selection

In the process of index selection, taking into account the status of Ningbo-Zhoushan port, this paper selects representative indicators such as port cargo throughput, GDP, added value of the secondary industry and actual utilization of foreign capital. Among them, cargo throughput reflects the production and operation status of the port and measures the development level of Ningbo-Zhoushan port. GDP reflects the regional economic situation and measures the comprehensive development level of the regional economy, the added value of the secondary industry represents the economic and industrial structure of the hinterland, which is an important indicator of regional economic activities, and the actual utilization of foreign capital represents the use of foreign capital in the economic hinterland.

In this paper, data from 2000 to 2022 are selected from China Statistical Yearbook and Zhejiang Provincial Statistical Yearbook. In order to avoid the impact of price factors on the test results, the Gross regional product index (GDP index) of Zhejiang Province is used to adjust the indicator data of regional product, as shown in **Table 1**:

Table 1. Nominal GDP, GDP Index and Real GDP of Zhejiang Province.

Year	GDP (Hundred million RMB)	GDP Index (Last year = 100)	Real GDP (Hundred million RMB)
2000	6164.79	111.10	6164.79
2001	6927.70	110.70	6824.42
2002	8040.66	112.70	7691.12
2003	9753.37	114.70	8821.72
2004	11482.11	113.10	9977.36
2005	13028.33	112.90	11264.44
2006	15302.68	114.00	12841.47
2007	18639.95	114.50	14703.48
2008	21284.58	110.05	16181.18
2009	22833.74	109.00	17637.49
2010	27399.85	111.90	19736.35
2011	31854.80	109.00	21512.62
2012	34382.39	108.10	23255.14
2013	37334.64	108.30	25185.32
2014	40023.48	107.70	27124.59
2015	43507.72	107.96	29283.70
2016	47254.04	107.50	31479.98
2017	52403.13	107.76	33922.83
2018	58002.84	107.10	36331.35
2019	62462.00	106.80	38801.88
2020	64689.06	103.60	40198.75
2021	74040.78	108.70	43696.04
2022	77715.36	103.20	45094.31

Source: Zhejiang Provincial Bureau of Statistics.

In this paper, C represents the annual cargo throughput of Ningbo-Zhoushan port, G represents the gross product of the economic hinterland of Zhejiang Province, S represents the added value of the secondary industry in the economic hinterland of Zhejiang Province, and F represents the actual utilization of foreign capital in the economic hinterland of Zhejiang Province.

3. Empirical Study on the Interactive Development of Economy between Ningbo-Zhoushan Port and the Hinterland

3.1. Model Establishment

Based on the data of Ningbo-Zhoushan Port and its hinterland, the VAR model of Ningbo-Zhoushan Port's impact on the economy of the hinterland region is established, and Granger test is used to verify the causal relationship between GDP (G), Added Value of the Secondary Industry (S), Actual Utilization of Foreign Capital (F) and Port Throughput (C) of the hinterland region.

The VAR model is usually used to predict the correlation time series system and the dynamic influence of random disturbance on the vector system. The VAR model constructs the model by taking each variable in the system as the lag value of all endogenous variables in the system, thus extending the univariate regression model to the "vector" autoregressive model composed of multivariate time series variables. The expression of the VAR model with the lag order p is as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + BX_t + \mu_t$$

where, Y_t is the K -dimensional endogenous variable vector; X_t is the D -dimensional exogenous variable vector; μ_t is the K -dimensional error vector; A_1, A_2, A_p , and B is the matrix of the coefficients to be estimated.

In order to avoid drastic changes of data, natural logarithm processing was performed for each sequence first, and the new sequences were recorded as LnC, LnG, LnS and LnF respectively. First, Stata18 software was used to make a simple analysis of the data. According to **Figure 3**, it can be seen that the cargo throughput, actual GDP and added value of the secondary industry of Ningbo-Zhoushan Port from 2000 to 2022 show a rising trend, and the rising trend is basically consistent. However, compared with 2005, the cargo throughput of Ningbo-Zhoushan Port increased significantly in 2006, and the GDP and the added value of the secondary industry increased more steadily than the cargo throughput of the port. Compared with the first three, the actual utilization of foreign capital fluctuated greatly, continuously decreased from 2006 to 2009, and showed a significant decline in 2019. Since 2019, it has shown a faster growth rate, and its growth rate is much higher than that of the cargo throughput.

In order to prevent pseudo-regression, ADF test is used to test the stationary of time series, and then residual series co-integration test is used to test the co-integration relationship, so as to determine whether there is a long-term equilibrium relationship between port cargo throughput and GDP, added value

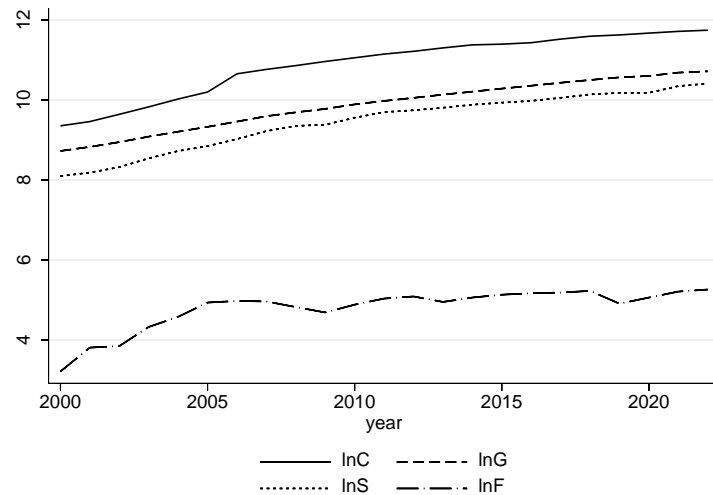


Figure 3. Line Chart of lnC, lnG, lnS, lnF from 2000 to 2022.

of the secondary industry and actual utilization of foreign capital. On the basis of the cointegration test, Granger causality is used in this study to verify the causality between port hinterland GDP, added value of the secondary industry, actual utilization of foreign capital and port throughput.

3.2. ADF Test

The traditional regression analysis of non-stationary time series will appear the phenomenon of “pseudo-regression”, so the stationarity test is carried out before the econometric analysis. In this paper, the most commonly used Augmented Dickey-Fuller (ADF) test method was used to conduct the stationarity test of development level index of Ningbo-Zhoushan Port and the three economic variables of Zhejiang Province, and the optimal lag order was determined according to AIC, HQIC, SBIC and other parameters. The ADF test was carried out using Stata18 software. The test results are shown in **Table 2**:

Table 2. ADF test results.

Variable	T-Statistic	1%CV	5%CV	10%CV	Stationarity
lnC	-3.682	-3.750	-3.000	-2.630	Yes
lnG	-7.147	-3.750	-3.000	-2.630	Yes
lnS	-3.273	-3.750	-3.000	-2.630	Yes
lnF	-4.702	-3.750	-3.000	-2.630	Yes

It can be seen from the stationarity test results that the four variables lnC, lnG, lnS and lnF are all stable, lnC and lnS are stable at the significance level of 5%, lnG and lnF are stable at the significance level of 1%. The ADF test shows that the time series data are stationary. Next, we further test whether there is a co-integration relationship between these variables.

3.3. Residual-Based Test for Stationarity

Residual sequence ADF test and co-integration test results. The stationarity test was carried out by Stata18 software, as shown in the following table.

Table 3. Residual-based test for stationarity.

T-Statistic	1%CV	5%CV	10%CV
-1.938	-2.660	-1.950	-1.600

As can be seen from **Table 3**, its ADF value is -1.938 , which is less than the 10% significance level of -1.600 , indicating that the null hypothesis that there is no co-integration relationship cannot be rejected, so the next Granger causality test can be carried out.

3.4. Granger Causality Test

The preceding co-integration relationship has proved that there is a long-term stable equilibrium relationship between the development of Ningbo-Zhoushan port and the economic development of Zhejiang Province, so whether there is a causal relationship between the two, whether the development of Ningbo-Zhoushan port causes the economic growth of Zhejiang Province, or whether the economic growth of Zhejiang province promotes the development of Ningbo-Zhoushan Port, or whether the two are mutually causal. Further research is needed.

Based on the Granger causality test principle, Stata18 software is used to analyze the causality between LnC, LnG, LnS and LnF during 2000-2022, and the results are shown in **Table 4**.

Table 4. Granger-causality test.

VAR Granger Causality	f-statistics	Lags	Prob.	Conclusion
LnC does not Granger Cause LnG	56.27	3	0	Refuse
LnG does not Granger Cause LnC	2.5799	3	0.461	Accept
LnC does not Granger Cause LnS	20.736	3	0	Refuse
LnS does not Granger Cause LnC	0.24025	3	0.971	Accept
LnC does not Granger Cause LnF	2.7613	3	0.43	Accept
LnF does not Granger Cause LnC	17.251	3	0.001	Refuse
LnG does not Granger Cause LnS	11.401	3	0.01	Refuse
LnS does not Granger Cause LnG	66.168	3	0	Refuse
LnG does not Granger Cause LnF	3.9273	3	0.269	Accept
LnF does not Granger Cause LnG	116.87	3	0	Refuse
LnS does not Granger Cause LnF	4.699	3	0.195	Accept
LnF does not Granger Cause LnS	26.245	3	0	Refuse

As can be seen from the table, the Granger causality test with a lag of three periods at a significant level of 5% indicates that there is a one-way Granger causality between LnC, LnG, LnS and LnF during 2000-2022, that is, the growth of port cargo throughput is the cause of economic growth of Zhejiang Province. However, there is no Granger causality between economic growth and port throughput growth.

Table 4 shows that the growth of port throughput is the Granger cause of economic growth in Zhejiang Province, while economic growth is not the Granger cause of port throughput growth; the growth of port throughput is the granger cause of the added value of the secondary industry in Zhejiang Province, but the added value of the secondary industry is not the granger cause of the growth of port throughput; the growth of port throughput is not the Granger reason for the actual utilization of foreign capital, but the actual utilization of foreign capital is the Granger reason for the growth of port throughput; the actual utilization of foreign capital and economic growth are granger reasons for each other; the economic growth of Zhejiang province is not the granger cause of the actual utilization of foreign capital, but the actual utilization of foreign capital is the Granger cause of economic growth; the added value of the secondary industry is not the Granger cause of the actual utilization of foreign capital, but the actual utilization of foreign capital is the Granger cause of the added value of the secondary industry.

In other words, the growth of port cargo throughput is the cause of the economic growth and the growth of the added value of the secondary industry in Zhejiang Province, but there is no Granger causality between economic growth and port cargo throughput.

4. Conclusions and Suggestions

4.1. Conclusions

This paper studies the interactive development of Ningbo-Zhoushan port and Zhejiang Province's economy. First, port throughput is selected as an indicator of port development through literature review, and the GNP, added value of secondary industry and actual utilization of foreign capital of Zhejiang Province are variables of economic development. Based on the time series data, this paper analyzes the linkage between the development of Ningbo-Zhoushan port and economic development. Secondly, the co-integration test and Granger causality test are used to make an empirical study on the economic growth of Ningbo-Zhoushan port and Zhejiang Province. The main conclusions are as follows.

1) The co-integration test shows that there is a long-term stable dynamic equilibrium relationship between Ningbo-Zhoushan port and regional economic development; In the long run, the throughput of Ningbo-Zhoushan port is in the same direction as the gross national product (GNP), added value of the secondary industry and the amount of foreign capital actually utilized in Zhejiang Province. The growth of the port throughput of Ningbo-Zhoushan port has a

strong promoting effect on the economic growth of Zhejiang Province. The above analysis fully reflects the promoting effect of the port on the hinterland economic development.

2) Granger causality test shows that the port throughput of Ningbo-Zhoushan port is the Granger reason for the economic growth of Zhejiang Province, but the economic growth of Zhejiang Province is not the Granger reason for the development of Ningbo-Zhoushan Port, which indicates that the economic development of Zhejiang province has no significant driving effect on the development of Ningbo-Zhoushan Port. The possible reasons for this phenomenon are that the private economy of Zhejiang Province is developed, the living standard of residents is high, and the economic development is not highly dependent on export, which limits the driving role of the port.

4.2. Suggestions

From the above analysis, it can be seen that the development of port can promote the development of hinterland regional economy, and port is often the growth pole of regional economic development. Due to the agglomeration effect of port development on hinterland regional economy, it will guide the rapid development of hinterland regional economy through the multiplier effect. However, according to the empirical research, it can be seen that Ningbo-Zhoushan port has not fully played its role in stimulating the economy of Zhejiang Province. In order to further play the role of Ningbo-Zhoushan port in promoting the economy of Zhejiang Province, the following suggestions are put forward:

1) Further consolidate and expand the economic hinterland

Port and hinterland economic development complement each other. a) Consolidate the economic hinterland in the province. Ningbo-Zhoushan Port needs to further gather various advantageous resources, such as logistics and shipping services, to promote the surrounding regional container route network. At the same time, starting from the hinterland, Ningbo-Zhoushan port planning and the surrounding hinterland economy should be combined, the advantages of interaction between the port and the stomach should be given full play, and the advantages of geographical location of the port should be relied on to form a good and efficient interaction. b) Expand the economic hinterland. Change the direction of the development of the hinterland, focusing on roads, railways and canals, improve the level of port logistics services, improve the construction of the hinterland cargo collection system serving the Yangtze River Delta and radiating inland provinces, and expand the scope of the economic hinterland.

2) Increase investment in port construction and develop port logistics

World port development practice has proved that port logistics is the trend of modern port development. First of all, by increasing the investment in port logistics infrastructure, it can directly or indirectly affect the cost and efficiency of other production sectors, so as to stimulate the economic growth. Secondly, by exerting the effect of economic agglomeration, port logistics forms logistics in-

dustry cluster, so that logistics enterprises can form an alliance, effectively integrate and optimize resources, so that resources can be used to the maximum. Finally, the development of port logistics can not only improve the efficiency of commodity transportation, but also reduce transportation costs, save transaction costs, improve the quality of port service, realize the smooth flow of goods, avoid the backlog of goods and other problems, and provide a strong guarantee for the smooth progress of foreign trade. Ningbo-Zhoushan Port has become one of the largest ports in China and has the superior conditions for vigorously developing port logistics. Further increasing investment and promoting the development of port logistics of Ningbo-Zhoushan Port is of great significance for promoting the economic development of Zhejiang Province.

3) Promote the port alliance and promote the linkage development of port groups

Although the total amount of resources of the port shoreline in the Ningbo-Zhoushan region is relatively rich, after years of development, the capacity of the shoreline has been near saturation, and the excellent port shoreline for development is constantly decreasing. The undeveloped shoreline is restricted by various factors, and there are problems of difficult development and high cost, which should not be over-developed. Therefore, relying on the surrounding ports, promoting the port alliance and promoting the linkage development of port groups can not only make up for the lack of space of Ningbo-Zhoushan port, but also enable the ports to form misplaced development in function and avoid waste of resources. In addition, further coordination with the development strategy of the Yangtze River Economic Belt, the construction of Zhejiang Pilot Free Trade Zone and the construction of the “Belt and Road”, accelerate the integration of Ningbo-Zhoushan port into the integrated development process of the Yangtze River Delta, and drive the development of southeast coastal port groups, thus greatly promoting the economic development of Zhejiang Province.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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