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An Empirical Study on the Impact of Port on Hinterland Economy

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Abstract

This study focuses on Shanghai Port as the subject of investigation, employing measurement methods such as co-integration theory and Granger causality test, impulse response analysis, and variance analysis. It utilizes data from 2000 to 2022 and selects indicators related to both Shanghai Port and the economic development of its hinterland in order to examine their relationship. The research results indicate that there is a stable dynamic equilibrium relationship between Shanghai Port and hinterland economy development. In the short term, Shanghai Port has a certain promoting effect on hinterland economic growth; however, in the long term, there is no significant evidence to suggest that the growth of the hinterland economy significantly promotes the development of Shanghai Port. Through variance decomposition analysis, it can be observed that the development of Shanghai Port has a stronger influence on the Actual Utilization of Foreign Capital in its hinterland compared to GDP and the Value-added of Tertiary Industry. Building upon these results, this paper also offers recommendations for fostering interactive development between Shanghai Port and its hinterland economy, which can serve as valuable guidance for relevant stakeholders and decision-makers.

Keywords

Hinterland Economy, Shanghai Port, Vector Autoregression Model, Impulse Response Function, Variance Decomposition

1. Introduction

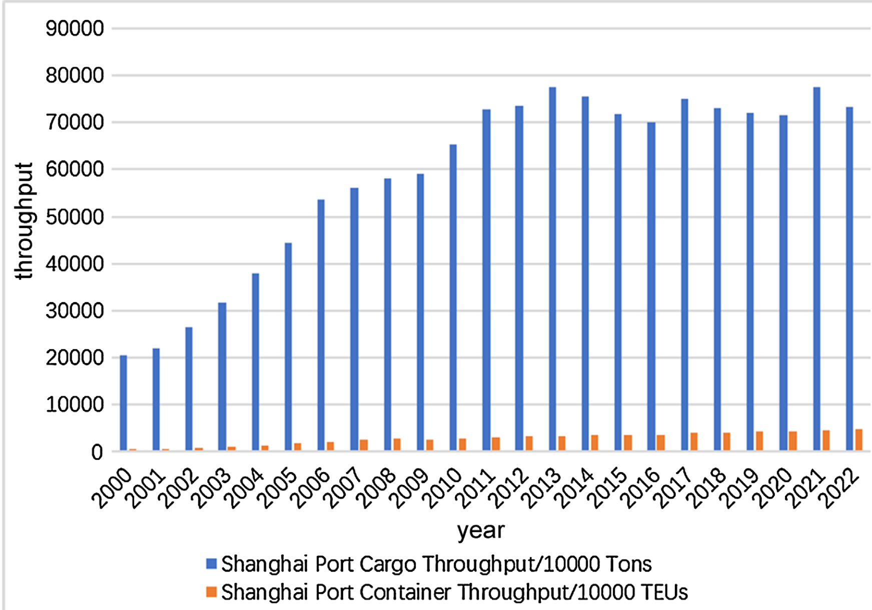
As the global trade gateway, ports play a pivotal role in serving national strategies and supporting economic development. Shanghai Port is one of the ports with the largest container throughput and cargo throughput in the world, as well as the largest cargo distribution and gathering place of goods in China, it is strategically located in the economically prosperous Yangtze River Delta Region. Shanghai Port holds significant importance in driving the country's economic and social progress. Given its crucial role in our nation's economic development and foreign trade, studying the symbiotic relationship between Shanghai port and hinterland economy bears practical significance by offering valuable insights for fostering economic interaction among other ports.

Scholars' studies on the impact of port development on hinterland economy can be traced back to 1934, when German scholar Goetz established the theory of seaport location based on the relationship between port and hinterland in his "Seaport Location Theory". He believed that with the high development of economy, hinterland factors played a decisive role in seaport location. Later, scholars studied the relationship between port and hinterland economy from different perspectives, most of which focused on the impact of port on the macroeconomic of hinterland region. For example, Seabrooke et al. (2003) used the data of Hong Kong Port from 1983 to 1999 to predict the impact of urban economy on port throughput by regression analysis method in 2003. It was concluded that the economic development of the Pearl River Delta would greatly increase the cargo throughput of Hong Kong Port. Coppens et al. (2007) studied the influence of Antwerp Port on hinterland economy by using the method of regional input-output, and proposed the interaction between the port and various industries in hinterland economy to promote the development of hinterland economy. Schempf (2008) believed that Fourchon Port played a key role in American economy. Bottasso, et al. (2014) investigated the panel data of forty-one ports in European and analyzed the impact of port cargo throughput and passenger flow on the number of employment, the results showed that port cargo throughput was positively correlated with employment rate. Cong et al. (2020) investigated the relationship between port throughput and urban economic by using dynamic panel model and causality test. Jung (2011) reviews the main literature on port city interface and studies the input-output linkage effect of port, based on the empirical data of port throughput and economic indicators, and discusses the relationship between port and economic performance of major port cities in South Korea. The study indicates that the convenience of readily available port services cannot guarantee economic success of the cities where ports are located. Local economies may no longer benefit much from nearby ports. Santos et al. (2018) presented a method of assessing the economic impacts of ports at both regional level and national level, through application of input-output analysis. They confirmed the significance of this port to the Portuguese economy, and also demonstrated that the influence of the Port of Lisbon is mostly limited to an area in close proximity to the port. Danielis & Gregori, (2013) identified the main economic and industrial characteristics of the port system of the Friuli Venezia Giulia (FVG) Region, Italy, and the role it plays within the economy. Jun et al. (2018) applied a modified hybrid methodology combining Delphi surveys and input-output analysis, estimated the economic impact of the smart port industry on the Korean economy with a sophisticated yet reasonable range of values. The study indicated that compared with the port industry, the smart port industry has an especially large impact on productivity, value added, and employment. Jouili & Allouche (2016) used an econometric model by employing the Cobb-Douglas production function, estimated the impact of seaports investment on the economic growth, the sample was composed of Tunisia's economic sectors (manufacturing, services and agriculture) over the period 1983-2011. The results of the study showed that the public investment in seaport infrastructures has a positive influence on Tunisian economic growth.

By conducting a comprehensive literature review, significant advancements have been made in both theoretical and empirical research on the interactive development of port and hinterland economy. The quantitative research methods employed primarily encompass input-output models, econometric techniques, and system dynamics methodologies. However, it is worth noting that most studies predominantly adopt static analyses which fail to objectively capture the dynamic changes occurring within port and hinterland economy, thus hindering a comprehensive understanding of their evolutionary patterns. Furthermore, existing dynamic studies tend to focus solely on establishing co-integration relationships between ports and hinterland economy without delving into the intricacies of their interdependencies, resulting in relatively simplistic conclusions. In light of this gap in knowledge, this paper aims to use Granger causality tests to analyze the causal relationship between Shanghai Port and its hinterland economy while employing impulse response analysis and variance decomposition to assess Shanghai Port's contribution to the development of its hinterland economy. These findings provide new insights for further research in this field while enriching its content with reliable theoretical basis and practical value for stakeholders. The remaining of the study is structured as follows.

2. Overview of Shanghai Port

As the pivotal port in the Yangtze River Delta region and a shipping hub extending to both the Yangtze River Economic Belt and nationwide, Shanghai Port has witnessed an augmented international status and influence subsequent to China's accession to WTO. It has emerged as a crucial nexus connecting China with the global community. Since 2000, there has been a consistent upward trajectory in Shanghai Port's overall throughput (As depicted in **Figure 1**). Since 2000, Shanghai Port handled a cargo throughput of 204 million tons along with a container throughput of 5.61 million TEUs. By 2023, the cargo throughput of Shanghai Port will reach 760 million tons, accompanied container throughput of 49.16 million TEUs, maintaining its position as the world's foremost port for fourteen consecutive years.



Data Source: China Port Yearbook.

Figure 1. The Throughput of Shanghai Port from 2000 to 2022.

3. Determination of Economic Hinterland of Shanghai Port and Selection of Indicators

3.1. Determination of Hinterland of Shanghai Port

The hinterland of the port refers to the area encompassing cargo handling and passenger distribution, playing a pivotal role in driving and radiating the surrounding economy for port development. Shanghai Port boasts an extensive direct economic hinterland due to its exceptional geographical advantages and economic strengths. According to the official website of Shanghai Port and previous research findings, its direct economic hinterland includes Shanghai, Jiangsu, and Zhejiang provinces (See Figure 2). While Shanghai serves as the core hinterland, Jiangsu and Zhejiang provinces act as major sources of goods for Shanghai Port, making them common hinterlands as well. Situated at the Yangtze River Delta region with solid industrial foundation, developed commodity economy, and convenient land-water transportation systems, it represents an area with remarkable comprehensive economic capacity. In terms of total economic volume within this hinterland, real GDP has exhibited a consistent trend of rapid growth from 1,953.1 billion RMB in 2000 to 14,495.6 billion RMB in 2022. Furthermore, there has been continuous optimization in terms of industrial structure within this hinterland as it successfully transitioned from secondary industry dominance to tertiary industry prominence; evident by an increase in added value from 783.8 billion RMB in 2000 to 13,731 billion RMB in 2022. The utilization of foreign capital also witnessed substantial growth from 12.07 billion RMB in 2000 to reach 73.75 billion RMB by year-end-2022.

Source: Regional Map of China.

Figure 2. Shanghai Port hinterland.

3.2. Selection of Indicators

In the process of index selection, considering Shanghai Port's positioning as an international port and its background as a free trade zone, this study incorporates previous research findings and selects indicators such as cargo throughput (C), hinterland GDP (G), value-added of tertiary industry (T) in the hinterland, and foreign investment in actual use (F). Among these indicators, cargo throughput (C) reflects the operational status of the port and measures the development level of Shanghai Port. GDP (G) reflects hinterland economy growth and measures the comprehensive level of hinterland economy development. The value-added of tertiary industry (T) represents the economic and industrial structure of the hinterland, serving as a crucial indicator for hinterland economy activities. Foreign investment in actual use (F) reflects the utilization level of foreign capital in the hinterland and plays a significant role in promoting economic development.

The time series data from 2000 to 2022 were extracted from various sources, including the China Statistical Yearbook, Shanghai Statistical Yearbook, Jiangsu Statistical Yearbook, and Zhejiang Statistical Yearbook. In this study, C denotes the cargo throughput of Shanghai Port, G represents the GDP of the hinterland region, T signifies the value-added of tertiary industry in the hinterland region, and F indicates foreign investment in actual use of the hinterland region.

In order to mitigate the impact of price factors on the test results, the GDP index is employed to adjust the GDP of Shanghai, Jiangsu and Zhejiang, yielding the adjusted real GDP. To address data volatility and eliminate heteroscedasticity, a logarithmic transformation is applied to convert the time series into LogC, LogG, LogT, and LogF respectively. Descriptive statistical analysis of the data is conducted using Stata 18 with specific results presented in **Table 1**.

Table 1. Descriptive statistical analysis of variables.

Variable	Observations	Mean	Std.dev.	Min	Max
LogC	23	10.91606	0.4218005	9.925249	11.25977
LogG	23	11.03925	0.642354	9.879739	11.88419
LogT	23	10.57806	0.9360156	8.966716	11.83
LogF	23	6.103853	0.4969488	4.793572	6.603331

The results presented in **Table 1** demonstrate that the mean LogC value for the period spanning from 2000 to 2022 is calculated as 10.91606, accompanied by a standard deviation of 0.4218005. These findings suggest that the logarithmic distribution of cargo throughput at Shanghai Port exhibits a notable level of concentration, displaying minimal fluctuations over the years. Moreover, similar patterns of concentration are observed in the logarithmic values pertaining to Shanghai Port's GDP, the Value-added of Tertiary Industry, and the Actual Utilization of Foreign Capital within its economic hinterland.

4. Empirical Analysis of Interactive Economic Development of Shanghai Port and Its Hinterland

4.1. Stationarity Test

Due to the possibility of "spurious regression" in the time series, we employed Stata 18 to perform a stationarity test on the Shanghai Port Development Index and three economic variables in the hinterland, and using the widely adopted ADF (Augmented Dickey-Fuller) test method. The results of this test are presented in **Table 2**, where LogC, LogG, LogT, and LogF exhibit statistical significance at the 1% level with p-values less than 0.05. Consequently, reject the null hypothesis of unit root existence and establish that LogC, LogG, LogT, and LogF represent stationary data series that satisfy the prerequisites for conducting cointegration analysis. As a result, we can proceed with subsequent tests.

4.2. Unit Root Test

Based on AIC and BIC minimum criteria, it is judged that the optimal lag order of the VAR model in this paper is third order. Next, the stability of the VAR model will be further judged. The unit Root test is shown in **Figure 3**.

Table 2. ADF test results.

Variable	T-Statistic	1% CV	5% CV	10% CV	P-value	Stationarity
LogC	−4.968	−3.750	−3.000	−2.630	0	Yes
LogG	−6.657	−3.750	−3.000	−2.630	0	Yes
LogT	−4.072	−3.750	−3.000	−2.630	0.0011	Yes
LogF	−5.350	−3.750	−3.000	−2.630	0	Yes

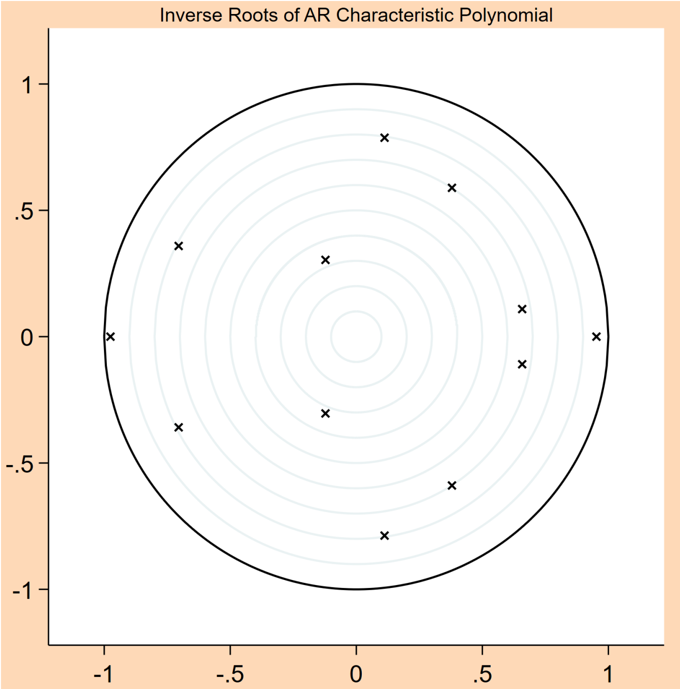


Figure 3. Unit root test.

It can be seen from **Figure 3** that the data is stable only when the unit root is less than 1. As can be seen from the unit circle, the unit root is all less than 1 and within the unit circle. Therefore, the model established in this paper is stable.

4.3. Granger Causality Test

The pre-literature study has proved that there is a stable equilibrium relationship between Shanghai Port and the hinterland economy, and the unit root test proves that the data is stable. Then, whether there is a causal relationship between Shanghai Port and the hinterland economy, it is the development of Shanghai Port causes the growth of the hinterland economy, or the growth of the hinterland economy promotes the development of Shanghai Port, and what is the interactive relationship between them, further research is needed.

Based on the Granger causality test principle, Using Stata 18 software to analyze the causality between LogC, LogG, LogT and LogF from 2000 to 2022, the result is shown in **Table 3**.

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 causal relationship between LogC, LogG, LogT and LogF, the hinterland economy can lead to the increase of the cargo throughput (C). The cargo throughput (C) can lead to the increase of GDP (G) and foreign investment in actual use (F).

Table 3. Granger-causality test.

Null Hypothesis	F-statistics	Prob.	Conclusion
LogG does not Granger Cause LogC	11.915	0.008	Reject
LogC does not Granger Cause LogG	9.7883	0.020	Reject
LogT does not Granger Cause LogC	9.7072	0.021	Reject
LogC does not Granger Cause LogT	2.3839	0.497	Accept
LogF does not Granger Cause LogC	10.894	0.012	Reject
LogC does not Granger Cause LogF	19.874	0	Reject
LogT does not Granger Cause LogG	38.448	0	Reject
LogG does not Granger Cause LogT	24.497	0	Reject
LogF does not Granger Cause LogG	0.98948	0.804	Accept
LogG does not Granger Cause LogF	21.04	0	Reject
LogF does not Granger Cause LogT	3.0088	0.390	Accept
LogT does not Granger Cause LogF	18.284	0	Reject

Based on Table 3, the results showed that: (1) The port cargo throughput (C) is not the Granger cause of the value-added of tertiary industry (T), the P-value is 0.497, the null hypothesis is rejected; (2) The foreign investment in actual use (F) is not the Granger cause of hinterland GDP (G), the P-value is 0.804, the null hypothesis is accepted; (3) The foreign investment in actual use (F) is not the Granger cause of the value-added of tertiary industry (T) in hinterland, the P-value is 0.39, the null hypothesis is rejected. In addition, the results of Granger causality test are all accepted. The hinterland GDP (G) is the Granger cause of port cargo throughput (C), the value-added of tertiary industry (T) and the foreign investment in actual use (F). The hinterland GDP (G) and the value-added of tertiary industry (T) are the uni-directional Granger causes of the foreign investment in actual use (F).

From the perspective of economics, the results of Granger causality test show that the growth of hinterland GDP, the value-added of tertiary industry (T) in hinterland and foreign investment in actual use (F) have obvious effects on promoting cargo throughput growth, and the promoting effects are similar. It can be seen that the hinterland economic growth can effectively promote the development of port, but the growth of the port cargo throughput cannot effectively promote the growth of the value-added of tertiary industry (T) in hinterland. It can be seen that although port development and hinterland economy growth have a strong synergistic effect, but haven't formed a sustainable virtuous cycle.

4.4. Impulse Response and Variance Decomposition

VAR models can analyze the dynamic impact of random disturbances on system variables. Due to the difficulty in interpreting individual parameter estimates for complex economic issues, VAR models are typically evaluated using impulse response analysis and variance decomposition. Next, we will conduct impulse response analysis and variance decomposition on time series data to understand their long-term trend of influence.

4.4.1. Impulse Response

Impulse response refers to the reaction a system exhibits when subjected to an external shock. By examining the changes in other variables after experiencing an external shock through impulse graphs, we can understand the effects that this shock has on the variables.

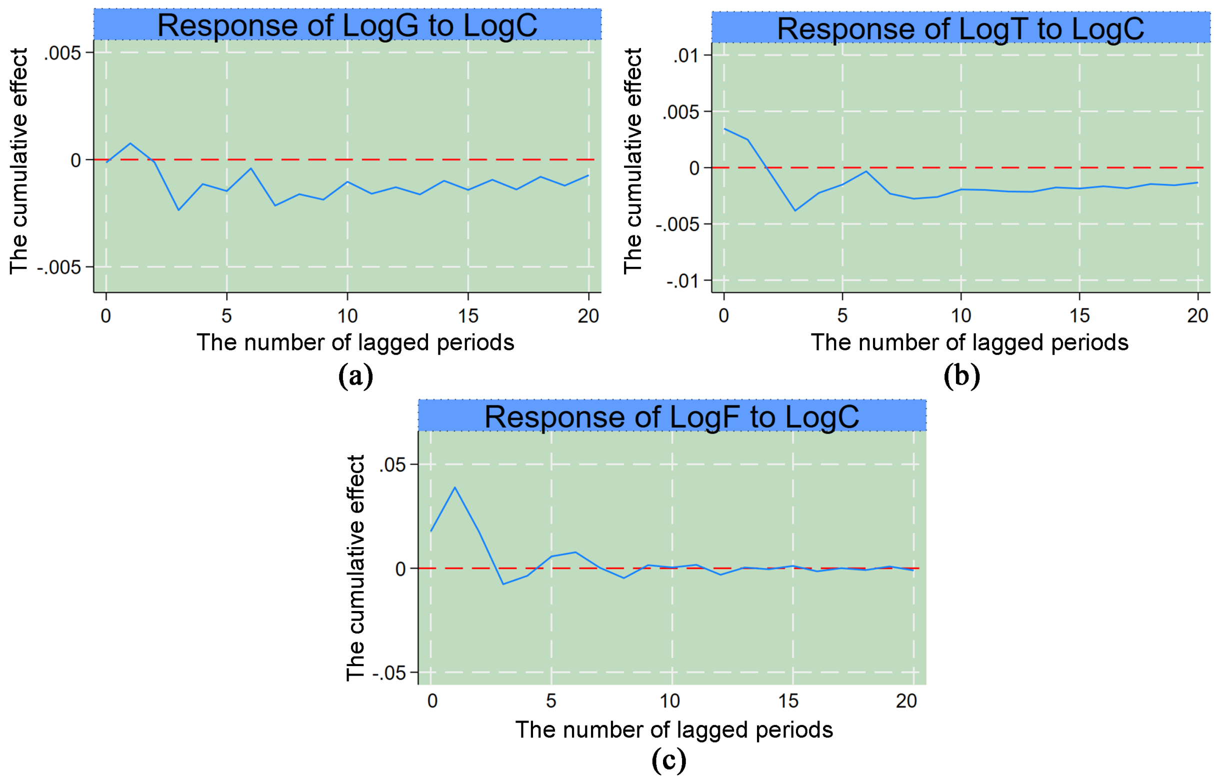


Figure 4. Response of the pulse. (a) Impulse Response of LogC to LogG; (b) Impulse Response of LogC to LogT; (c) Impulse Response of LogC to LogF.

The pulse response graph in Figure 4(a) shows the relationship between GDP and port cargo throughput. According to Figure 4(a), it can be observed that when there is a positive shock to cargo throughput, GDP exhibits a positive response in the first two periods, reaching its peak in the first period and then transitioning into a maximum negative response in the third year. Subsequently, it demonstrates a negative effect, but starting from the seventh period, the negative impact gradually weakens. This indicates that an increase in port cargo throughput drives GDP growth in the short term. However, as the economy expands, port development has a slight inhibitory effect on economic performance.

The pulse response graph in Figure 4(b) shows the relationship between the added value of the tertiary industry and the throughput of port cargo. According to Figure 4(b), it can be observed that when there is a positive shock to the cargo throughput, the GDP exhibits a positive response in the first two periods but then shows a negative effect from the third period onwards. From the seventh period onwards, this negative impact gradually weakens. This result is similar to the pulse response of LogC to LogG. As part of GDP, it is not difficult to explain why there is such an effect on the added value of the tertiary industry.

Figure 4(c) shows the impulse response graph of actual foreign investment utilization on port cargo throughput. According to Figure 4(c), it can be observed that after a positive shock is given to the current period's port throughput, the growth of actual foreign investment gradually converges after reaching its maximum positive level in the second period. This indicates that in the short term, there is a lag effect of port cargo throughput on actual foreign investment. The increase in throughput has a significant driving effect on the growth of actual foreign investment, but this driving effect will weaken over time. Positive responses are formed in periods one to three, while negative responses are formed in periods three to five and seven to nine respectively, with maximum positive and negative responses reached in periods two and three. From period nine onwards, convergence gradually occurs. This suggests that a positive shock to port throughput has a greater impact on actual foreign investment in the short term and exhibits some volatility overall. In general, port cargo throughput has a positive driving effect on attracting foreign investment.

4.4.2. Variance Decomposition

The impulse response function characterizes the influence of a shock in one endogenous variable on other endogenous variables within a VAR model. To assess the contribution of each structural shock to changes in endogenous variables and evaluate the significance of different structural shocks, it is imperative to establish a forecast variance decomposition model. Variance decomposition entails an information calculation process that dissects the mean square deviation of predictions for each variable into contributions made by system shocks. It enables us to depict the relative importance of shocks in dynamic changes pertaining to regional economic growth, value added by tertiary industry, actual utilization of foreign capital, and port cargo throughput. Building upon the aforementioned VAR model, we conducted variance decomposition and present our findings in Figure 5.

Figure 5 demonstrates that, when excluding its own contribution, the cargo throughput of Shanghai Port exhibits the highest contribution rate to its effective utilization of foreign investment. Figure 5(a) reveals that the contribution rate of cargo throughput to the hinterland's GDP is approximately 15%, with lower rates observed in the initial three periods, essentially at zero. The contribution rate gradually increases and stabilizes from the tenth period onwards. Figure 5(b) illustrates that the contribution rate of cargo throughput to value added by tertiary industry eventually reaches a stable level around 20%, with a slight decrease in the third period followed by a gradual increase starting from the seventh period. Figure 5(c) depicts that, without considering its own contribution rate, cargo throughput displays the highest impact on actual utilization of foreign investment, peaking in the second period at over 50%. However, it exhibits a declining trend in subsequent periods and maintains a relatively steady level from the eighth period onwards. These findings suggest that Shanghai Port's development exerts stronger influence on actual utilization of foreign investment within its hinterland compared to its impact on GDP and value added by tertiary industry.

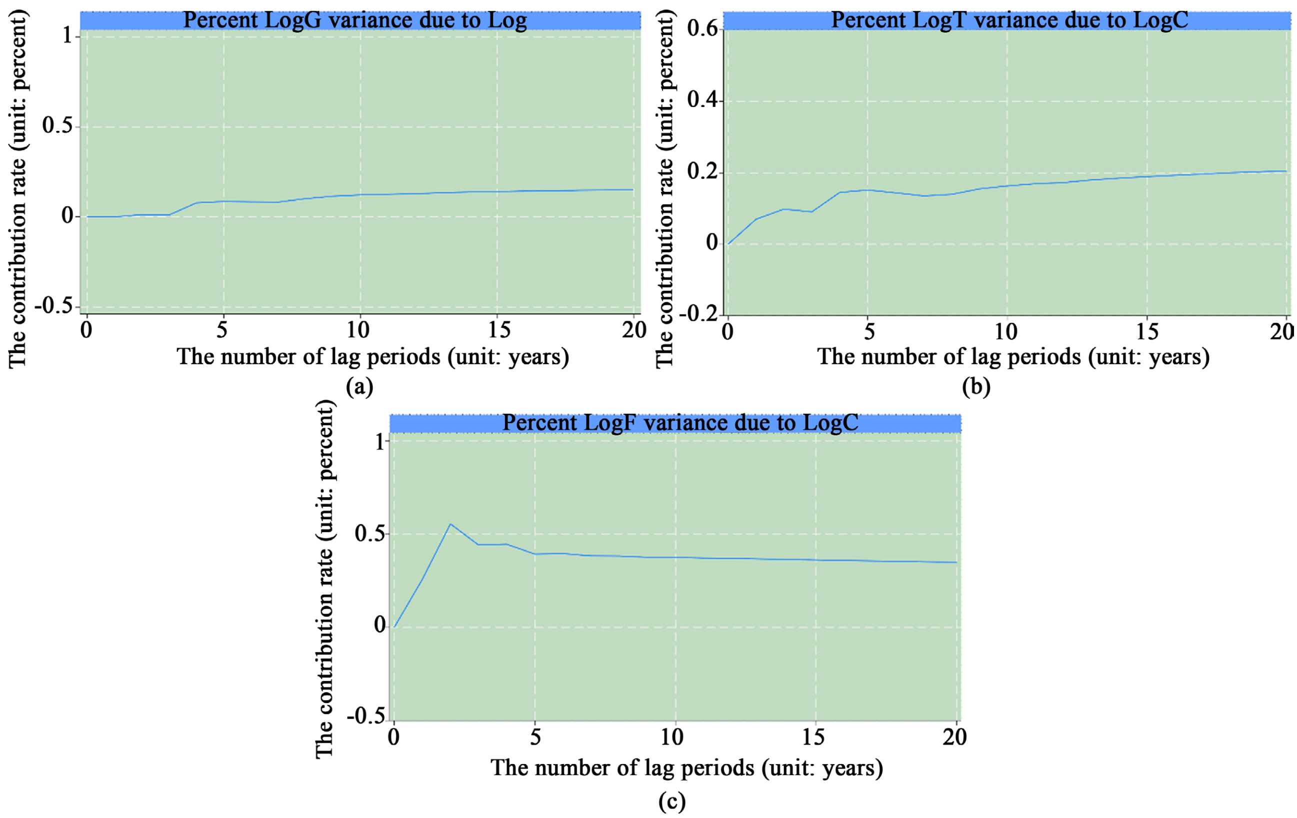


Figure 5. Variance decomposition graph. (a) The contribution rate of LogC to LogG; (b) The contribution rate of LogC to LogT; (c) The contribution rate of LogC to LogF.

5. Conclusions and Suggestions

5.1. Conclusions

This study examines the interactive development between Shanghai Port and the hinterland economy. Firstly, after conducting a comprehensive literature review, we selected GDP (G), Value-added of Tertiary Industry (T), and Actual Utilization of Foreign Capital (F) in Shanghai, Zhejiang, and Jiangsu as variables for assessing hinterland economy development. By analyzing time series data in conjunction with the development of Shanghai Port and the hinterland economy, we aim to explore their coordinated developmental relationship.

Secondly, used the Granger causality test to identify the internal relationship between the development of Shanghai Port and hinterland economy. The conclusion shows that there is a stable equilibrium relationship between hinterland GDP (G), the Value-added of Tertiary Industry (T), the Actual Utilization of Foreign Capital (F) and the cargo throughput of Shanghai Port (C). The hinterland GDP (G) and the Actual Utilization of Foreign Capital (F) have two-way Granger causality relationship with the cargo throughput of Shanghai Port (C), however the cargo throughput of Shanghai Port (C) has uni-directional Granger causality relationship with the Value-added of Tertiary Industry (T). The cargo throughput of Shanghai Port (C) is not the Granger cause of the Value-added of Tertiary Industry (T) of the hinterland.

Ultimately, the findings from impulse response and variance analysis demonstrate that in the short term, Shanghai Port exerts a positive influence on the economic growth of its hinterland. However, over the long run, the development of Shanghai Port may even exhibit an inhibitory effect on the hinterland economy, suggesting a gradual attenuation of this promoting impact as the economy expands. Through variance decomposition, it is evident that Shanghai Port's most significant impact lies in actual utilization of foreign capital within its hinterland, while its influence on gross domestic product and value added in tertiary industry is comparatively weaker.

5.2. Suggestions

1) Optimize the spatial layout of ports to facilitate their sustainable development. Ports should promptly adapt to the demands of hinterland industries and economic growth by enhancing transportation systems, fortifying port information networks, and bridging the gap between ports and hinterland economy development. The focal point lies in cultivating high-end shipping services, expanding the range of port services, improving value-added services at ports, guiding the concentration of high-value-added shipping elements, and further reinforcing hub functions.

2) Enhance the synergy between port development and industrial growth. The full potential of ports in promoting the tertiary industry has not been fully realized, as the tertiary sector is a crucial component of port economy. Ports should transition from solely providing services to developing into multifunctional service systems that encompass transportation, finance, information, consumption, tourism, and more. This will foster a novel pattern of mutual promotion and coordinated development between ports and their hinterland economy, facilitating continuous transformation and upgrading of both industries.

3) Promote economic growth and establish a foundation for the interaction between ports and hinterland economy. Empirical results indicate a bidirectional

Granger causality relationship between the GDP of the hinterland, actual utilization of foreign investment, and cargo throughput. Enhancing economic growth and increasing the actual utilization of foreign investment positively impact the efficiency of port-hinterland interaction. By harnessing economic development potential, fostering regional cooperation, facilitating orderly flow of economic factors, and optimizing resource allocation, we can effectively promote sustained and stable development of the hinterland economy.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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