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# Modeling and Analysis the Competition Dynamics among Container Transshipment Ports
## : East-Asian Ports as a Case Study*

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## Abstract

This study examines the competitiveness and cooperativeness among the container ports in East Asia by analyzing their monthly dynamics in eight years (2008-2015). Time series data on container throughput divided into origin and destination (O/D), such as the top six Chinese ports and the transshipment (T/S) ports such as Hong Kong, Busan, and Singapore, are computed with two methods based on the Vector Error Correction Model (VECM). The first Granger causality test results show that Busan T/S has significant bilateral relations with three Chinese O/D ports; and significant unidirectional relations with three other O/D ports. Shenzhen port has significant bilateral relations with Singapore, and has a significant unidirectional relation with Hong Kong port. Co-integrating test results showed that Busan holds negative co-integration with all Chinese O/D ports. Impulse response function (IRF) results show an opposite direction between paired ports. The ratios of the impulse from T/S ports are significantly high to one another in the short-run, but its power declines as time passes. The ratio of the impulse from the Chinese ports to T/S ports is less significant in the short-run period, however, it becomes more significant as time passes. The significance of most shocks was high in the second period, but was diluted after the sixth period.

*Key words: Port competition, Container throughput, Co-integrating test, Granger causality, Impulse response function, Vector error correction model, Long-run relationship*

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## Ⅰ. Introduction

International trade has played an significant role for economic development of East Asian countries. The economic development with successful trade strategies of East Asian countries, such as Japan, Singapore, Hong Kong, South Korea and China led to expand the trade globally. It opened an opportunity to container ports to show their strong container handling performances.

The competition among container ports being as a hub port was for a long time not very comprehensive because ports are located in specific areas. However, with the increasing ratio of transshipment traffic the geopolitical- sensitiveness of container ports has been transformed, and competition among ports has boosted up. Ports are now not only competing with nearby ports, but also with ports relatively far away(Liu, 2010).

Till 2000, the competitiveness of being hub port was among Hong Kong, Kaohsiung, Singapore, Busan and Yokohama. But the high demand for the affluent Chinese raw and industrial commodities led Shanghai, Ningbo-Zoushan, Shenzhen and Tianjin ports to become leaders in the East Asian region. Their rapid growth dropped the market share of other competitive ports nearby them.

This study is organized as follows. First, we shortly outline the situation in East Asian port competition and define transshipment competition. Second, we provide a literature review on port competitiveness, and then conduct studies that use using co-integration test to analysis the port competition, and lastly we perform our main aim and objectives. Then we analysis the competition through the Granger causality test, impulse response function and Vector error correction model. At last we summarize the study with forwarding implementations to Busan Port Authority. The study would help to terminal operators, shipping liners and shippers to formulate new strategic decisions.

## Ⅱ. Literature Review

Port choice is determined by main players in logistic chain system. Scholars pointed towards shipping lines and shippers are main key players in determining the choice of ports (Yap, 2006). Ports are one part of a value driven chain system and they offer feasible value to its users against other competing value driven chain systems. As a node in the logistic chain, transshipment ports are chosen as the port of call. The hinterland accessibility, productivity, quality, cargo generating effect, reputation and reliability are critical in enhancing a port's competitiveness (Haezendonck & Notteboom, 2002). Moreover, city-port interface, government policy, global economy with changes of production and distribution channels, technology, port users' behavior, pricing, environmental issue, as well as security and safety (Lee & Lam, 2015) are useful to evaluate the competitiveness of container ports.

According to the geographical situation, East Asian ports located in high contiguity, and the main transshipment container ports extend beyond their continental limits by contributing to nearby regions. Busan, Hong Kong, Kaohsiung and Singapore ports serve not only to themselves, but also provide feeder services to China mainland and nearby island ports. Economic benefits generated from competitive port will have cascading efficiency gains for both its O/D hinterlands through the supply chain systems using the port (Haynes et al., 1997).

The improvement of low price and service quality could lead to intense the competition; however, the opportunities are urged for ports to cooperate to better serve the general economic interests of their hinterland (Yap, 2006). The studies on relative competitiveness of East Asian container ports implemented using a number of methods, such as including time series analysis (Yap, 2006; Park, 2009), DEA and SFA methods (Notteboom, 2002; Lee & Lam 2015), survey of container ship operators and logistics managers, marginal cost pricing approach, annualized slot capacity (Notteboom, 2012) and game theory (Song, 2002; Ishii et al., 2013; Song, 2016). Lam(2002) proposed a model on cooperation strategies to respond shipping lines with increasing bargaining power and port competitions and found Hong Kong and Yantai ports to generate positive effects on each other's container throughput. Next Yap and Lam (2004) showed another model for analyzing inter-container port relationships and affirmed the positive advances to strengthen a port's competitive position. Yap and Lam(2006) also found that Hong Kong and Busan are beneficiaries from inter-port competition on the cargo volume which shifts China mainland in long term by using VAR & VECM models. Park(2009) found that Busan and Kaohsiung have complementary relationship for China, Japan and US O/D containers by using co-integration test. Recently, Tian et al. (2015) found competitive environment between Shenzhen and Hong Kong ports using Granger causality test.

Few studies attempted to find out the nature of container port competition in East Asia with connecting the growth of Chinese ports. Yap and Lam(2006) predicted that inter-port competition in East Asia region would increase in the future and the center of gravity of cargo volume shift to mainland China. However, they did not study any of Chinese ports in analyzing the dynamics of competition in the region. Tongzon and Chang(2007) attempted to study the impact of the growth of China ports' container volume for the Busan and found that it has been reducing the hub status of Busan port because major shipping lines did more direct ship calls at the Chinese ports. Moreover, although there have been few studies on the adverse effects of Chinese port growth on the hub ports of Hong Kong, Kaohsiung and Busan, there has so far no systematic study of its impact on the port of Singapore (Tongzon, 2011).

Although numerous studies have investigated on competitiveness among transshipment ports, and among export and import ports, but the relationship between O/D and T/S ports have not been investigated yet. This paper undertakes such an investigation for the first time in containership market. The results of the investigations will be helpful to port authorities, terminal operators, government officials to make decision for long run period.

The main aim of the study is to model and analyze the dynamic competitiveness among the East-Asian transshipment ports through the impact of Chinese major ports.

The objectives of the study:

1) to find the competition through transshipment cargoes among the East Asian ports focusing on the impact of Mainland China (O/D container) ports to transshipment ports;

2) to model the short and long causal relationship among ports by using updated monthly time series data.

## Ⅲ. Materials and Methodology

The container port competition can be different due to the variety of factors. Due to complexity of the factors, we attempt to establish the modelling of dynamics of transshipment of container port competition in East Asia.

We focused to choose major and effective ports in East Asia dividing into O/D and T/S. Here, we need to explain about O/D and T/S ports. Port of origin is defined as the port where a shipment actually originated; and port of destination is defined as the intended final arrival port of a ship or shipment. Transshipment ports focuses mainly to transfer a shipment from one vessel to another which will then carry the shipment to their final destination. Due to the main operation type, all six of China Mainland ports are selected as O/D ports, and other three non-Chinese ports are selected as T/S ports with using only their T/S container volume. However, we cannot find the relevant data on O/D and T/S volume in Chinese ports and Singapore port, so that we used all monthly data as O/D for Chinese Ports (due to over 80% of containers are accounted as O/D) and as T/S for Singapore (due to 81%-85% of containers are accounted as T/S) based on relative articles and yearbooks. The monthly data set is collected from Korea Maritime Institute yearbooks in the recent 8 years from 2008 till 2015. Most of previous studies on port competitiveness studied the period when containership market size had increased due to high demand in East Asia, especially in China, till the global financial crisis from 2007 to 2009. However, after worldwide economic difficulties in the containership market with low demand, the new competitiveness period started among the containership port. This recession in the container market continued till 2015, when Intra-Asian trade volumes have again returned to more robust growth following disturbance in the Chinese economy. Global container trade growth is on track to accelerate slightly in 2016, following subdued expansion in 2015. (Clarkson Review) The collected data covers the containership performance in major East Asian ports in the recent recession period.

The analyzing process will be computed in EViews 9.0 application in following stages:

Firstly, we use the white noise analysis to stretch the time series data to random walk condition from random shock condition. Unit root test is used to establish the stationarity properties of the data sets. The Augmented Dickey Fuller(ADF) test critical values is useful because unit root tests can be affected by power and size problems, so non-rejection of a unit root does not imply acceptance.

Table 1. Data set on O/D and T/S ports and research period

| Data set | Ports | Selected data |
|---|---|---|
| O/D ports | Shanghai | Full as O/D |
| | Shenzhen | Full as O/D |
| | Ningbo-Zhoushan | Full as O/D |
| | Qingdao | Full as O/D |
| | Tianjin | Full as O/D |
| | Guangzhou | Full as O/D |
| | Busan | Only O/D part |
| | Hong Kong | Only O/D part |
| T/S ports | Busan | Only T/S part |
| | Hong Kong | Only T/S part |
| | Singapore | Only T/S part |
| Period | Jan/2008 - Dec/2015, Monthly | |

Note: As the limited data on actual numbers of Singapore T/S throughput monthly, we only used the given T/S share according to the articles from journals and books in related years.

See also:

1. Bookbinder J. H. Handbook of Global Logistics: Transportation in International Supply Chains. Springer Science & Business Media, 2012. p.469
2. World's Main Intermediate Hubs and Markets, 2007-2012 at www.people.hofstra.edu
3. Shanghai may pip Singapore as busiest port, China Post on July 15, 2010 at www.chinapost.com.tw
4. In Pictures: Top 5 Transshipment Hubs, Port Technology updated on February 25, 2015 at www.porttechnology.com
5. Singapore PA: Core Business atwww.singaporepsa.com

Secondly, we use Granger causality test to deal with in the context of VECM model. Granger emphasize that whether a variable $A$ affects a variable $B$, the $A$ should help improving the predictions of the $B$ variable.

$t$ is the all relevant information set available up to and including period $t$. $z_t(h|\Omega_t)$ be the optimal (minimum MSE) $h$-step predictor of the process $z_t$ at origin $t$, based on the information in $t$. The corresponding forecast $MSE$: $\sum_t(h|\Omega_t)$.

The process $A_t$ is said to cause $B_t$ in Granger's sense if $\sum_t(h|\Omega_t) < \sum_t(h|\Omega_t\{x_s : s \leq t\})$ for at least one $h = 1,2,\ldots$. $\Omega_t\{x_s : s \leq t\}$ is the all relevant information set except for the information in the past and present of the $A_t$ process. If $B_t$ can be predicted more appropriately and the data in the $A_t$ process is accounted in addition to all other information in the set, then $A_t$ is Granger-causal for $B_t$.

Lastly, we investigate impulse response function analysis which refers to the response of a T/S port to an impulse in another O/D and T/S ports. It draws out the causality type by outlining the effects of exogenous shocks in one port on other ports. If there is a reaction of a T/S port to an impulse in another O/D and T/S ports, then it is called the O/D and T/S ports causal for the T/S port.

$$TS_{t+n} = \sum_{t=0}^{p} B_i \epsilon_{t+n-i}$$

$$\{B_n\}_{i,j} = \frac{\partial TS_{+n}}{\partial \epsilon_{jt}}$$

where the response of port to a one-time impulse in with all other O/D and T/S ports dated $t$ held constant. The response of T/S port $i$ to a unit shock in O/D port $j$ is described a graphical visualization of the dynamic interrelationships.

Thirdly, we conduct co-integration tests which refers to a linear combination of variables to check non-stationary with a relationship between variables. No co-integration indicates the lack of long-run equilibrium among the variables. For $k$ endogenous variables, each of which has one unit root, there will be 0 to $k-1$ co-integrating relations. We use the Johansen Maximum Likelihood procedure for estimating multiple co-integrating vectors. To illustrate the Johansen method, consider the Vector Error Correction Model (VECM) of order $p$:

$$\Delta TS_{A,t} = \alpha TS_{A,t-1} + \sum_{i=1}^{p-1} \beta_i \Delta TS_{A,t-1} + \gamma X_t + \epsilon_t$$

For $\alpha = \sum_{i=1}^{p} A_i - I,\ \beta_i = -\sum_{j=i+1}^{p} A_j;$

$X_t = OD_t \text{ or } TS_{B,t}$

where $TS_t$ denotes a $k \times 1$ vector of $I(1)$ variables, $\alpha_i$ and $\beta$ denote $k \times k$ matrices of unknown parameters to be estimated, $\gamma$ denotes a $k \times h$ matrix, $X_t$ denotes a $h \times 1$ vector of $I(0)$ variables, and $\epsilon_t$ denotes a vector of error terms. As VECM represents the correlations among a set of variables, the number of co-integrating vectors can be established by the $k_{trace}$ and $k_{\max imum}$ statistics. The linear combination of two co-integrated variables can be represented by the co-integrating equation(CE):

$$TS_A = \alpha + \beta X_B + \hat{e}_t$$

where $TS_A$ denotes the container throughput handled by T/S port $A$, $X_B$ denotes the container throughput handled by O/D & other T/S ports, $\alpha$ denotes the constant term, $\beta$ denotes the long-term inter-port relationship, and $\hat{e}_t$ denotes the residual.

## Ⅳ. Empirical results

The data set covers the major 6 Chinese ports (include full TEU volume) and 3 large transshipment ports (include only T/S TEU volume) in 8 years period with 96 months.

We began with examining the stationarity of the given time-series data using ADF test (unit-root test). Based on AIC and SIC criteria, we arranged the time-differences with 2. We first set the data with level variable option.

$H_0$: There is a unit root for the series.

$H_a$: There is no unit root for the series. As the computed p-value is greater than the significance level alpha=0.05, we cannot reject the null hypothesis $H_0$ (Appendix 1), except Shenzhen port. Then we set the data to the 1st differential variables (lag=1), $H_0$ is rejected in all cases (Appendix 2). The ADF test results show that the monthly data are stationary when lag is equal to 1. Then we established paired combinations between ports using Granger causality test for each T/S port (lags=1). Granger causality test for Busan is described in 〈Table 2〉.

The result of granger causality test shows that since the $p-value$ is low than 0.05, Chinese O/D ports do Granger cause Busan T/S very significantly with Shanghai (0.000), Shenzhen (0.000) and Ningbo-Zhoushan (0.009). It shows that Chinese O/D ports affect significantly the future performance of Busan T/S. Conversely, Busan T/S also does Granger cause Chinese O/D ports' future performance with very significant probabilities, such as Shanghai (0.000), Shenzhen (0.001), Ningbo - Zhoushan (0.000), Qingdao (0.000), Tianjin (0.000) and Guangzhou (0.000). Among T/S ports, Hong Kong port does significant Granger cause to Busan (0.002).

Table 2. Granger causality for Busan T/S

| A | B | Obs. | Prob. |
|---|---|---|---|
| Hong Kong T/S | Busan T/S | 93 | 0.002** |
| Busan T/S | Hong Kong T/S | 93 | 0.917 |
| Singapore T/S | Busan T/S | 93 | 0.123 |
| Busan T/S | Singapore T/S | 93 | 0.080 |
| Shanghai O/D | Busan T/S | 93 | 0.000** |
| Busan T/S | Shanghai O/D | 93 | 0.000** |
| Shenzhen O/D | Busan T/S | 93 | 0.000** |
| Busan T/S | Shenzhen O/D | 93 | 0.001** |
| Ningbo O/D | Busan T/S | 93 | 0.009** |
| Busan T/S | Ningbo O/D | 93 | 0.000** |
| Qingdao O/D | Busan T/S | 93 | 0.414 |
| Busan T/S | Qingdao O/D | 93 | 0.000** |
| Tianjin O/D | Busan T/S | 93 | 0.232 |
| Busan T/S | Tianjin O/D | 93 | 0.000** |
| Guangzhou O/D | Busan T/S | 93 | 0.883 |
| Busan T/S | Guangzhou O/D | 93 | 0.000** |

Note: $H_0$: Port A does not Granger cause Port B
* denotes rejection of the hypothesis at the 0.05 level
** denotes rejection of the hypothesis at the 0.01 level

Next, the results of Granger causality test are given for Hong Kong T/S in ⟨Table 3⟩.

The neighbouring port Shenzen (0.003) do Granger cause to the performance of Hong Kong T/S, while Hong Kong T/S does Granger cause Guangzhou (0.018), Qingdao (0.006), Tianjin (0.022) and Shanghai (0.032) ports significantly. Moreover, Hong Kong T/S does Granger cause to Singapore T/S (0.046) too.

Table 3. Granger causality for Hong Kong T/S

| A | B | Obs. | Prob. |
|---|---|---|---|
| Singapore T/S | Hong Kong T/S | 93 | 0.309 |
| Hong Kong T/S | Singapore T/S | 93 | 0.046* |
| Shanghai O/D | Hong Kong T/S | 93 | 0.287 |
| Hong Kong T/S | Shanghai O/D | 93 | 0.032* |
| Shenzhen O/D | Hong Kong T/S | 93 | 0.003** |
| Hong Kong T/S | Shenzhen O/D | 93 | 0.479 |
| Ningbo O/D | Hong Kong T/S | 93 | 0.293 |
| Hong Kong T/S | Ningbo O/D | 93 | 0.434 |
| Qingdao O/D | Hong Kong T/S | 93 | 0.721 |
| Hong Kong T/S | Qingdao O/D | 93 | 0.006** |
| Tianjin O/D | Hong Kong T/S | 93 | 0.389 |
| Hong Kong T/S | Tianjin O/D | 93 | 0.022* |
| Guangzhou O/D | Hong Kong T/S | 93 | 0.714 |
| Hong Kong T/S | Guangzhou O/D | 93 | 0.006** |

Note: $H_0$: Port A does not Granger cause Port B

Lastly, the results of Granger causality test for Singapore T/S port are described in ⟨Table 4⟩.

Table 4. Granger causality for Singapore T/S

| A | B | Obs. | Prob. |
|---|---|---|---|
| Shanghai O/D | Singapore T/S | 93 | 0.163 |
| Singapore T/S | Shanghai O/D | 93 | 0.005** |
| Shenzhen O/D | Singapore T/S | 93 | 0.000** |
| Singapore T/S | Shenzhen O/D | 93 | 0.000** |
| Ningbo O/D | Singapore T/S | 93 | 0.850 |
| Singapore T/S | Ningbo O/D | 93 | 0.016* |
| Qingdao O/D | Singapore T/S | 93 | 0.263 |
| Singapore T/S | Qingdao O/D | 93 | 0.461 |
| Tianjin O/D | Singapore T/S | 93 | 0.097 |
| Singapore T/S | Tianjin O/D | 93 | 0.504 |
| Guangzhou O/D | Singapore T/S | 93 | 0.714 |
| Singapore T/S | Guangzhou O/D | 93 | 0.733 |

Note: $H_0$: Port A does not Granger cause Port B

According to the results above, only Shenzhen port (0.000) do Granger cause Singapore T/S over the period. However, Singapore T/S significantly does Granger cause to Shenzhen (0.000), Shanghai (0.005) and Ningbo-Zhoushan (0.016) ports.

Summing up the Granger causality test for the effect performance among container ports, we can divide the results into four groups. Note the Granger causality test does not express the positive or negative effect between two ports. Firstly, major two of Chinese O/D ports, Shenzhen and Shanghai, do Granger cause to all T/S ports significantly. Secondly, Busan T/S and Singapore T/S do cause significantly Ningbo -Zhoushan ports' container throughputs. Thirdly, Busan T/S and Hong Kong T/S affect significantly for Qingdao, Tianjin and Guangzhou O/D container throughputs. Lastly, Hong Kong T/S directly does Granger cause to other transshipment ports over the period.

Assembling the significant results of Granger causality test, we calculated the co-integrating equations (CE) among paired combinations. The co-integrating test represents the relationship in long-run period. Here, the co-integrating equations results are divided into 2 groups: 4 of them are accounted as bilateral relations and other 12 of them are explained as the unidirectional relations part. The co-integrating test results on bilateral relationship are given in 〈Table-5〉.

The co-integrated test results suggest that Busan T/S and three of Chinese O/D ports Shanghai, Shenzhen and Ningbo-Zhoushan are co-integrated with high probability at 0.01 level. Singapore T/S and Shenzhen ports are also co-integrated at the 0.05 level. Hence, these ports affect significantly to each other in long- run period.

Table 5. Co-integration test results for bilateral relation

| Port pair | Lag interval | Eigen value | Trace statistic | Prob. | Hypo-zed no. of CE(s) |
|---|---|---|---|---|---|
| Busan - Shanghai | 1 | 0.218<br>0.004 | 23.326<br>0.398 | 0.00<br>0.53 | None**<br>At most 1 |
| Busan - Shenzhen | 1 | 0.201<br>0.003 | 21.209<br>0.290 | 0.01<br>0.59 | None**<br>At most 1 |
| Busan - Ningbo | 1 | 0.239<br>0.003 | 25.695<br>0.252 | 0.00<br>0.62 | None**<br>At most 1 |
| Singapore Shenzhen | 1 | 0.127<br>0.031 | 15.555<br>2.889 | 0.05<br>0.09 | None*<br>At most 1 |

Note: Trace test indicates no co-integration at the 0.05 level

The co-integrating test results unidirectional relation in 〈Table 6〉 shows that Busan T/S port is co-integrated with Qingdao, Tianjin and Guangzhou ports at the 0.01 level. Shenzhen port and Hong Kong port are co-integrated with the probability at the 0.05 level. The other 8 of unidirectional relations are not co-integrated at the given level.

Table 6. Co-integrating test results for unidirectional relation

| Port pair | Lag inter-val | Eigen value | Trace statistic | Prob. | Hypothesi-zed no. of CE(s) |
|---|---|---|---|---|---|
| Busan-Qingdao | 1 | 0.221<br>0.001 | 23.306<br>0.119 | 0.003<br>0.730 | None**<br>At most 1 |
| Busan-Tianjin | 1 | 0.305<br>0.004 | 34.188<br>0.374 | 0.000<br>0.541 | None**<br>At most 1 |
| Busan-Guangzhou | 1 | 0.203<br>0.005 | 21.485<br>0.422 | 0.006<br>0.516 | None**<br>At most 1 |
| Hongkong-Busan | 1 | 0.067<br>0.001 | 6.524<br>0.053 | 0.634<br>0.819 | None<br>At most 1 |
| Shenzhen-Hongkong | 1 | 0.134<br>0.031 | 16.314<br>2.927 | 0.038<br>0.087 | None*<br>At most 1 |

| | | | | | |
|---|---|---|---|---|---|
| Hongkong-Shanghai | 1 | 0.087<br>0.001 | 8.562<br>0.062 | 0.407<br>0.804 | None<br>At most 1 |
| Hongkong-Qingdao | 1 | 0.062<br>0.002 | 6.201<br>0.213 | 0.672<br>0.644 | None<br>At most 1 |
| Hongkong-Tianjin | 1 | 0.070<br>0.017 | 8.333<br>1.569 | 0.431<br>0.210 | None<br>At most 1 |
| Hongkong-Guangzhou | 1 | 0.084<br>0.000 | 8.228<br>0.033 | 0.441<br>0.856 | None<br>At most 1 |
| Hongkong-Singapore | 1 | 0.101<br>0.030 | 12.775<br>2.838 | 0.123<br>0.092 | None<br>At most 1 |
| Singapore-Shanghai | 1 | 0.043<br>0.035 | 7.395<br>3.291 | 0.532<br>0.070 | None<br>At most 1 |
| Singapore-Ningbo | 1 | 0.087<br>0.028 | 11.072<br>2.611 | 0.207<br>0.106 | None<br>At most 1 |

Note: Trace test indicates no co-integration at the 0.05 level

Co-integrating equations test results show that the bilateral relations between pair ports are significantly negative, given in ⟨Table 7⟩.

Table 7. Pair-wise results for bilateral relations

| | SH | SZ | NB | Relationship |
|---|---|---|---|---|
| BT | -0.450 | n.a. | n.a. | Competitive |
| | n.a. | -0.995 | n.a. | Competitive |
| | n.a. | n.a. | -0.501 | Competitive |
| ST | n.a. | -1.630 | n.a. | Competitive |

We illustrated the relationship for this dataset in ⟨Fig. 1⟩.

Moreover, the co-integrating equation test results show that the four unidirectional relations are competitive with each other too, presented in ⟨Table 8⟩. While Busan port is competitive with Qingdao, Tianjin and Guangzhou O/D ports, Shenzhen port has a significant competitive relation with Hong Kong port. In turn, a rise in Shenzhen's container throughput has negatively impacted on Hong Kong T/S volume and the rise in Busan T/S port's container throughput has negatively impacted to three of Chinese ports in long-run period.

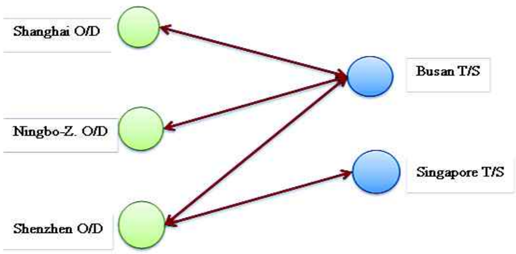


Fig 1. Visualized results of the significant co-integrated equations for bilateral relations

Note: ◀━▶ Competitive relation

◀┈┈▶ Complementary relation

Table 8. Pair-wise results for unidirectional relations

| | BT | SZ | Relationship |
|---|---|---|---|
| QD | -1.624 | n.a. | Competitive |
| TJ | -1.229 | n.a. | Competitive |
| GZ | -1.352 | n.a. | Competitive |
| HT | n.a. | -27.998 | Competitive |

We described results of the co-integrating equations visually for unidirectional relations in ⟨Fig.2⟩.

Next, we tested the impulse response function on the paired combinations, which are found as a significant effect through Granger causality test and co-integrating test results. Impulse response functions are used to describe how the port performance reacts over time to exogenous impulses, or shocks, whether there is a shock in one port to an impulse in another port. The ordering of the variables cannot be determined with statistical methods. It has to be such that the first variable is the only one with a potential immediate impact on all other variables. The second variable may have an immediate impact on the last $N-2$ components of $Y_t$ but not on $Y_{1t}$ and so on.

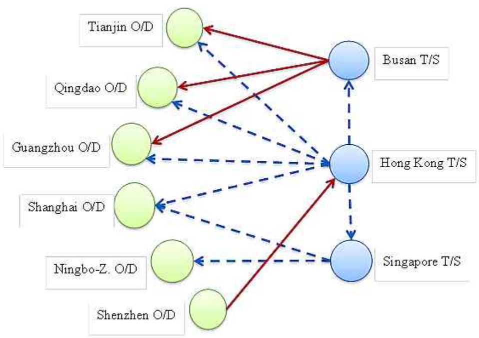


Fig 2. Visualized results of the significant co-integrated equations for unidirectional relation

Note: ⟶ Co-integrated, competitive relation

┈▶ Not co-integrated in pairs

Firstly, we calculated the unrestricted co-integrating coefficients and illustrated the impulse response functions for bilateral relations in ⟨Table 9⟩ and visualised in ⟨Fig 3⟩.

Table 9. Unrestricted co-integrating coefficients in bilateral relations

| Ports in pair | Unrestricted Co-integrating Coefficients |
|---|---|
| Busan<br>Shanghai | -0.020<br>+0.009 |
| Busan<br>Shenzhen | -0.007<br>+0.007 |
| Busan<br>Ningbo | -0.025<br>+0.013 |
| Singapore<br>Shenzhen | -0.004<br>+0.007 |

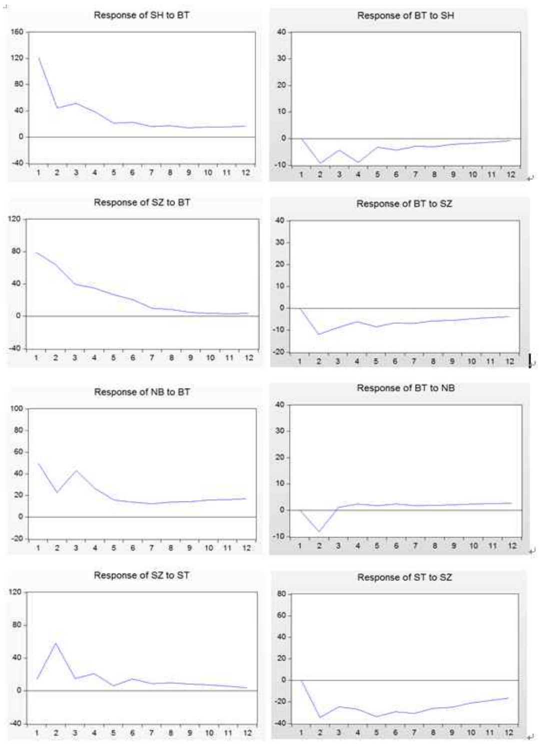


Fig 3. Impulse response functions for bilateral relations

Note: BT(Busan T/S), ST(Singapore T/S), SH(Shanghai O/D), SZ(Shenzhen O/D), NB(Ningbo-Zhoushan O/D)

The unrestricted co-integrating coefficients show the direction of the trend line. In the Busan & Shanghai case, Busan responds with negative (-0.020) to the a SD shock from Shanghai port, while Shanghai port responds with positive direction (+0.009) to the SD shock from Busan T/S.

Therefore, Busan T/S port responds negatively with -0.007 and −0.025 to the impulse shock from Shenzen and Ningbo-Zhoushan ports. Even the shock from Busan T/S effects negatively to Shenzhen and Ningbo-Zhoushan ports in short period, the average direction of the trend forwards positively with +0.007 & +0.0013 in long period. The average direction of the trend in

Singapore T/S to the shock from Shenzhen ports is negative, while it is represented positively in Shenzhen to the shock from Singapore T/S. They are also represented as competitive relation to each other. The opposed relationship is illustrated in Fig 3.

Table 10. Unrestricted co-integrating coefficients in unidirectional - relations

| Ports in pair | Unrestricted Co-integrating Coefficients |
|---|---|
| Busan<br>Qingdao | +0.028<br>-0.017 |
| Busan<br>Tianjin | +0.017<br>-0.014 |
| Busan<br>Guangzhou | +0.017<br>-0.012 |
| Shenzhen<br>Hongkong | +0.005<br>-0.0002 |

Then we calculated the unrestricted co-integrating coefficients and illustrated the impulse response functions for unidirectional relations in ⟨Table 10⟩ and visualized in ⟨Fig 4⟩. The results of unrestricted co-integrating coefficients for unidirectional relations shows that a SD shock to Busan T/S can negatively affect to Qingdao (-0.017), Tianjin (-0.014) and Guangzhou ports (-0.012).

Finally, we check up the Variance Decomposition(VD). It represents the change of the ratio of the impulse / shock as the passing time and it appears the significant value. the results of the VD in Appendix 3.

According to the VD results, each T/S ports has high degree of impulse with itself and their power declines by time passing. The ratio of impulse Busan T/S declines from 100% to 43.75% from 1st month to a year later, as Hong Kong T/S maintains from 74.15% to 45.81%.

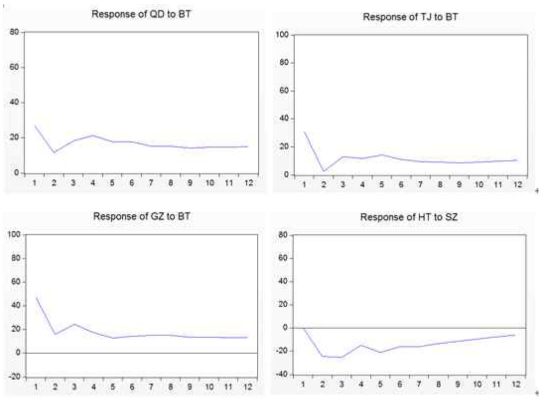


Fig 4. Impulse response functions for unidirectional relations

Note: BT(Busan T/S), HT(Hong Kong T/S), SZ(Shenzhen O/D), QD(Qingdao O/D), TJ(Tianjin O/D), GZ (Guangzhou O/D)

Th ratio of impulse of other T/S ports is less significant to Busan T/S port, but the ratio will increase to 4.75% from Hong Kong T/S and 1.17% from Singapore T/S. However, the ratio of the shock from Busan T/S declines from 25.85% in 1st month to 12.80% after a year. The shock ratio from Singapore T/S is less significant to Hong Kong T/S. Therefore, the shocks from Hong Kong and Busan T/S ports also decreases their power to Singapore T/S performance by passing time.

The more powerful shock comes from Qingdao port to Busan T/S port. Its ratio of the shock increases by time passes from 0% in first month to 17% after a year. The other significant impulses to Busan T/S port are from Shenzhen and Guangzhou ports.

In case of Hong Kong T/S port, the ratio of the shock from Shenzhen will increase significantly from 0 to 16% a year later. the ratio of the shock from Qingdao and Shanghai increase confidently in the long-run period.

Conversely to the ratio of the impulse from T/S ports, the ratio of the impulse from Shenzhen, Shanghai and Qingdao gives a significant effect to the Singapore T/S port performance. As time passes their shock ratio increases extremely, and it becomes 22.7% (Shenzhen), 15.8% (Shanghai) and 11.5% (Qingdao) a year later.

Summing up the results of VD, the ratio of the impulse from T/S ports is higher to each other in short run period, and declines their power as time passes. Interestingly, Busan's impulse appears significantly to Hong Kong and Singapore ports, but their affect occurs back to Busan in long-run with lower level. However, the ratio of the impulse from the Chinese ports to T/S ports is less significant in short run period, but it is becomes more significant as time passes.

## Ⅴ. Implementation

The research results show that there is significant competitive scene between O/D and T/S ports represented. However, we should note that O/D and T/S ports' performance is different from each other. As T/S volume can change due to the change of O/D port's performance; both port types can be competitive with same types of ports. But the research results presented that T/S ports keeps a complementary relation with each other, while Chinese O/D ports impact negatively to T/S ports' performance in long-run period. Main Chinese ports such as Shanghai, Shenzhen and Qingdao ports affect Busan port's future performance very significantly. Busan has today empowered up its strength by trans-shipping containers to Northern-East part of China. Summing up the empirical results, we can give some implementations to Busan port authority:

First, we can apply the container throughput of the other T/S ports' as a signal for Busan port. Because the more the container throughput increases in Singapore and Hong Kong ports, the more throughput increases in Busan port in long run term. as much container increases in Singapore, so much container throughput increases in Hong Kong and then in Busan. Due to the fact, we are able to forecast the throughput volume in short-run period. This gives us to think deeply on the port planning strategy.

Second, transshipment volume derive from O/D volume. Especially, Busan T/S has influenced significantly by Chinese O/D volume. Previous studies informed that the increase of T/S container throughput depends on the increasing volume of O/D ports, and they hold a complementary relation. Of course, we cannot deny the prior study results at all. However, the relationship maybe change partly by O/D volume size. Our study dataset (2008-2015) covers only the “recession” period with low demand in the container market. The relationship between O/D and Busan T/S port during the period is shown as a complementary, but the trend difference between them is increasing annually. In other word, as the container volume increases in O/D ports, so T/S ports lose their strength to maintain. So, the T/S ports should acknowledge that it has recently appeared a significant competitive relationship with O/D ports.

Third, if there is competitive environment between O/D and T/S ports, then Busan ports should create an complementary relation by alliancing with other T/S ports. Because the alliance is important for increasing the negotiation power in the covenant with the major shipping companies using Busan port. Therefore, it is favorable to attract to new shipping companies. So the alliance could help Busan PA seek an optimum T/S volume.

Fourth, if we assume that there is competitiveness between O/D and T/S ports, then enlargement of O/D size and entering more mega-ships to the container market cause to O/D port increase more direct calls from shipping companies than T/S ports. It is a natural phenomena. In these cases, T/S ports, especially Busan PA should find strong strategies to respond them.

Fifth, as mentioned above TEU volume of T/S ports origins from O/D ports, that means T/S ports play a distributive role between O/D ports and this makes them to depend on container transaction between O/D ports. To survive a long term in the market, T/S ports should find new strategies to becoming independence to O/D ports. T/S ports can apply shippers more distributive services, relevant time facilities, higher cost incentives and discounts within the port.

## VI. Conclusions

This article focused on modeling the dynamic competitiveness through the container transshipment among the major T/S in the East-Asia by the impact of Mainland China. By setting the VECM model out, we qualified to estimate the competitive environment using monthly stationary data. For the decision making, most ambitious work requires more qualified variables and appropriate data. We decided to use the container throughput as an essential quantitative data to figure out the competitiveness. Referencing articles on the competitive performance among ports, the competitiveness becomes only among hub ports and neighbor ports through years. However, this study covers major T/S ports under the impact of major Chinese O/D ports.

As ADF test found the selected data is stationarity, we analyzed Granger causality test and co-integration tests. Granger causality test results show that Busan T/S has significant bilateral-relations with three Chinese O/D ports; and significant unidirectional relations with other three O/D ports. Shenzhen port has significant bilateral relations with Singapore, and has significant unidirectional relation with Hong Kong port. Co-integrating test results represented that Busan holds co-integrated negatively with all Chinese O/D ports. Singapore port has co-integrated negatively with Shenzhen port.

IFR results represented an opposite direction between paired ports. Calculations of VD test show that the ratio of the impulse from T/S ports is higher to each other in short run period, and declines their power as time passes. However, the ratio of the impulse from the Chinese ports to T/S ports is less significant in short run period, but it is becomes more significant as time passes.

The research model examines the dynamics of T/S performance under the impact from O/D dynamics as a first time. But we cannot estimate the competition performance among ports in detail due to some limitations.

Firstly, we can estimate the export & import analysis using historical time series data, but it is not easy to predict future performance in the long-run period. As the co-integrating equation model is often used to analyze the macroeconomic performance; but the results on the container competition face to difficulties to predict appropriately in short-run period.

Secondly, as the container throughput performance depends on various demand factors such as port infrastructure, geographic location, present labor capacity, port charge price and other variables, but we used only data set on monthly container throughput.

Thirdly, differently from O/D ports, T/S container throughput of i port in t period, labor of other port, yard size could be more diversify; its results are also difficult to interpret in detail.

Lastly, O/D performance would increase due to market demand increase; T/S performance depends on how much cargo volume flow increases in the relevant market area during the period. So, T/S requires on what kind of strategy to judge the proper decision to create proficiency in the future. Because the infrastructure of the port demand a long period with high cost to build, the decision makers need to fully understand the nature of container flow in the long-run period.

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Appendex 1. Augmented Dickey-Fuller Test with level variable

| Augmented Dickey-Fuller Test | | | | | |
|---|---|---|---|---|---|
| MacKinnon critical values for rejection of hypothesis of a unit root<br>Included observations : 93 after adjusting endpoints | | | | | |
| Ports | t-value | AIC | SIC | Prob. | Result |
| BT | -0.650 | 10.309 | 10.418 | 0.853 | Accepted |
| HT | -2.474 | 11.990 | 12.099 | 0.125 | Accepted |
| ST | -1.929 | 12.266 | 12.375 | 0.318 | Accepted |
| SH | -1.820 | 13.787 | 13.896 | 0.369 | Accepted |
| SZ | -3.301 | 13.406 | 13.519 | 0.018 | Rejected |
| NB | -1.736 | 13.067 | 13.176 | 0.410 | Accepted |
| QD | -0.565 | 11.830 | 11.939 | 0.872 | Accepted |
| TJ | -2.028 | 12.440 | 12.549 | 0.275 | Accepted |
| GZ | -1.590 | 12.791 | 12.900 | 0.484 | Accepted |

Appendex 2. Augmented Dickey-Fuller Test with level variable with lag=1

| Augmented Dickey-Fuller Test | | | | | |
|---|---|---|---|---|---|
| MacKinnon critical values for rejection of hypothesis of a unit root<br>Included observations : 93 after adjusting endpoints | | | | | |
| Ports | t-value | AIC | SIC | Prob. | Result |
| BT | -9.362 | 10.292 | 10.374 | 0.000 | Rejected |
| HT | -10.439 | 12.034 | 12.116 | 0.000 | Rejected |
| ST | -8.131 | 12.286 | 12.367 | 0.000 | Rejected |
| SH | -10.388 | 13.802 | 13.835 | 0.000 | Rejected |
| SZ | -8.489 | 13.504 | 13.585 | 0.000 | Rejected |
| NB | -10.465 | 13.079 | 13.160 | 0.000 | Rejected |
| QD | -12.101 | 11.813 | 11.894 | 0.000 | Rejected |
| TJ | -9.127 | 12.463 | 12.545 | 0.000 | Rejected |
| GZ | -10.940 | 12.797 | 12.879 | 0.000 | Rejected |

Appendix 3. Results of Variance Decomposition (VD)

Variance Decomposition of HT:

| Period | S.E. | BT | HT | ST | SH | SZ | NB | QD | GZ | TJ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 33.59550 | 25.85323 | 74.14677 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 42.76076 | 21.13646 | 57.09666 | 3.994989 | 0.675200 | 5.921521 | 3.411121 | 1.797488 | 4.707355 | 1.259200 |
| 3 | 46.82277 | 17.78868 | 54.47907 | 3.444073 | 1.553340 | 10.04847 | 3.393479 | 1.530135 | 5.669889 | 2.092861 |
| 4 | 51.08647 | 16.77630 | 52.33316 | 3.203486 | 3.623836 | 10.91149 | 3.161925 | 2.665625 | 5.252109 | 2.072072 |
| 5 | 54.27366 | 15.41606 | 50.46358 | 2.972918 | 4.362565 | 13.02660 | 2.977843 | 3.884902 | 4.953716 | 1.941812 |
| 6 | 57.29380 | 14.57709 | 49.06283 | 2.821295 | 4.952866 | 13.97928 | 2.814636 | 5.263007 | 4.685978 | 1.843009 |
| 7 | 59.91847 | 13.97981 | 47.89092 | 2.690725 | 5.449380 | 14.89711 | 2.733638 | 6.123560 | 4.466299 | 1.768553 |
| 8 | 62.46286 | 13.52360 | 47.11920 | 2.598359 | 5.725531 | 15.42898 | 2.672105 | 6.909300 | 4.311451 | 1.711472 |
| 9 | 64.83449 | 13.22794 | 46.52075 | 2.535367 | 5.924088 | 15.80002 | 2.642378 | 7.478847 | 4.198643 | 1.671963 |
| 10 | 67.09307 | 13.02432 | 46.16044 | 2.504587 | 5.993280 | 16.00344 | 2.614045 | 7.936425 | 4.119157 | 1.644304 |
| 11 | 69.27079 | 12.89396 | 45.93489 | 2.490218 | 6.033380 | 16.10650 | 2.595224 | 8.253526 | 4.066416 | 1.625882 |
| 12 | 71.37097 | 12.80651 | 45.81310 | 2.496127 | 6.032137 | 16.16496 | 2.583163 | 8.459839 | 4.029512 | 1.614656 |

Variance Decomposition of BT:

| Period | S.E. | BT | HT | ST | SH | SZ | NB | QD | GZ | TJ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 82.11080 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 100.6682 | 74.70166 | 0.273052 | 0.881593 | 4.740745 | 7.586692 | 3.574827 | 0.242753 | 7.192155 | 0.806523 |
| 3 | 111.0794 | 69.76192 | 0.899405 | 0.908696 | 4.826408 | 9.792019 | 3.032118 | 2.581578 | 6.010498 | 2.187355 |
| 4 | 115.6023 | 61.73840 | 1.544742 | 0.776164 | 7.110978 | 9.691442 | 2.765423 | 6.540858 | 7.030400 | 2.801592 |
| 5 | 120.6794 | 57.18047 | 1.687044 | 0.739906 | 6.658595 | 10.96837 | 2.556339 | 9.783504 | 7.036807 | 3.388961 |
| 6 | 124.1314 | 53.33695 | 2.004204 | 0.667353 | 6.552254 | 11.18328 | 2.473206 | 12.17460 | 8.106339 | 3.501815 |
| 7 | 127.1619 | 50.67970 | 2.323012 | 0.686885 | 6.220845 | 11.53909 | 2.346574 | 13.64900 | 8.457437 | 4.097466 |
| 8 | 129.4431 | 48.68103 | 2.681518 | 0.690240 | 5.959760 | 11.47014 | 2.259317 | 14.83637 | 8.955034 | 4.466589 |
| 9 | 131.2039 | 47.01879 | 3.134453 | 0.782028 | 5.640729 | 11.38146 | 2.192288 | 15.67991 | 9.289917 | 4.880425 |
| 10 | 132.4641 | 45.71839 | 3.627593 | 0.888045 | 5.337086 | 11.11395 | 2.180178 | 16.37426 | 9.587929 | 5.172573 |
| 11 | 133.3460 | 44.62449 | 4.179794 | 1.026574 | 5.040895 | 10.80126 | 2.180497 | 16.82555 | 9.854974 | 5.465961 |
| 12 | 133.9557 | 43.75111 | 4.750930 | 1.173470 | 4.764097 | 10.45314 | 2.196335 | 17.11963 | 10.07740 | 5.713885 |

Variance Decomposition of ST:

| Period | S.E. | BT | HT | ST | SH | SZ | NB | QD | GZ | TJ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 92.73449 | 33.02546 | 16.04867 | 50.92587 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 115.3457 | 22.00809 | 11.39531 | 46.41362 | 3.224520 | 8.880306 | 1.949701 | 2.322269 | 2.050235 | 1.755944 |
| 3 | 125.9400 | 20.84558 | 11.34335 | 44.22265 | 4.198533 | 11.20046 | 1.678844 | 2.121011 | 2.913423 | 1.476148 |
| 4 | 137.7546 | 17.85472 | 9.730394 | 42.07835 | 9.318520 | 13.08598 | 1.420873 | 2.276639 | 2.974365 | 1.260161 |
| 5 | 147.1923 | 15.86114 | 9.423820 | 38.88294 | 10.78622 | 16.72671 | 1.398856 | 3.152305 | 2.616238 | 1.151766 |
| 6 | 156.5846 | 14.08195 | 8.711543 | 36.48963 | 12.93483 | 18.25372 | 1.284988 | 4.587465 | 2.637260 | 1.018613 |
| 7 | 164.0829 | 12.83124 | 8.440546 | 34.04442 | 13.82561 | 20.06336 | 1.282933 | 6.020645 | 2.494011 | 0.997244 |
| 8 | 170.5310 | 11.89802 | 8.221516 | 32.18735 | 14.49835 | 20.90193 | 1.238365 | 7.544870 | 2.557667 | 0.951926 |
| 9 | 175.6099 | 11.22590 | 8.103161 | 30.63297 | 14.74361 | 21.70907 | 1.228659 | 8.769025 | 2.616225 | 0.971387 |
| 10 | 179.5645 | 10.75821 | 8.029553 | 29.44944 | 14.84330 | 22.15600 | 1.202088 | 9.868039 | 2.702817 | 0.990553 |
| 11 | 182.6143 | 10.42839 | 7.958387 | 28.52422 | 14.84021 | 22.49132 | 1.181690 | 10.73266 | 2.800823 | 1.042302 |
| 12 | 184.9432 | 10.21293 | 7.894511 | 27.82144 | 14.77761 | 22.69981 | 1.160045 | 11.45123 | 2.884705 | 1.097707 |

Cholesky Ordering: BT HT ST SH SZ NB QD GZ TJ

# 컨테이너 환적 항만 간의 동태적 경쟁에 관한 연구
## : 동아시아 항만을 중심으로

아슈로프 압둘라지즈 · 김재봉 · 박남기

## 국문요약

본 논문은 동아시아의 주요 컨테이너항만 간의 경쟁 및 보완 관계를 분석하는 데 그 의의가 있다. 분석의 대상이 되는 항만들은 컨테이너 기종점 물동량 규모로 세계 최대인 중국의 6개 주요 항만과 환적 물동량 규모로 세계 최대인 싱가포르, 홍콩, 부산의 항만이며, 지리적으로는 동아시아에 밀집된 항만들이다. 본 연구에서는 2008년부터 2015년까지의 월간 컨테이너 물동량에 대한 시계열 자료를 이용하여 항만 간의 동태적 관계를 분석하였으며, 벡터오차수정모형(Vector Error Correction Model)에 기초하여 다음과 같이 분석하였다. 먼저 그랜저 인과관계 검정을 통해 항만 간의 상호관계를 규명하고자 하였다. 그리고 이어서 공적뿐 검정을 통해 관련 있는 두 항만 간의 장기적인 균형관계를 살펴보고자 했으며, 아울러 충격반응함수 및 표준변차의 분산분해 과정을 통해 단기적인 영향에 대해서 밝히고자 하였다. 결과를 살펴보면, 먼저 그랜저 인과관계 검정과 공적뿐 검정의 결과, 부산과 홍콩 및 싱가포르의 환적 물동량은 중국 내륙의 주요 기종점 물동량에 대해 상호적으로 또는 일방적으로 경쟁적인 관계가 있음을 보여주었다. 그러나 환적 물동량 간의 인과관계는 상호적으로는 유의미하게 나타나지 않았으며, 공적분도 존재하지 않았다. 다만 분산분해의 결과를 통해 단기적이고 부분적으로 충격에 차지하는 비중을 확인해 본 결과 홍콩항의 환적 물동량이 부산항과 싱가포르항의 환적 물동량에 차지하는 비중이 높아지고 있음을 알 수 있었다. 충격반응함수의 결과를 종합해 보면, 분석의 대부분에서 2기가 지나는 시점에 충격의 여파가 최대가 되며, 6기가 지나면서 그 충격은 소멸되었다. 본 연구에서 분석한 결과로 확인할 수 있는 것은 환적 항만 간의 관계가 경쟁적이라고 할 수 없다는 사실과 오히려 기종점 항만과 환적 항만의 경쟁 관계가 발생한다는 것이다. 이것은 기종점 물동량에 의해 파생된 환적 물동량이 기종점 물동량의 증가에 따라 항상 증가하지 않으며 오히려 감소될 수 있음을 설명하고 있다.

*주제어: 항만 경쟁, 컨테이너 물동량, 요한센 검정, 그랜저 인과관계, 벡터오차수정모형*