Analysis of competitive relationship among East Asian ports by Cointegration Test

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ABSTRACT

Expansion of port competition is growing very fast to attract more container throughput due to international specialization which MNCs have moved into low-cost cluster for saving cost and expanding market. East Asia is the center of this relationship because the ports in this region are connected in competitive or complementary relationship related to a number of container throughputs. This study shows the competitive relationship by cointegration test with time series data to prove the broad expansion of port competition. East Asian ports keep Hub & Spoke relationship for the past 20 years and multiple transshipment system has been introduced recently. Taiwanese ports are shrinking and Chinese Eastern ports are growing. This study identifies the role of Busan port as the hub port in Northeast Asia and the competitive relationship between Incheon and Chinese ports. This study shows the analysis of the past 20 years but don't deal with the fierce competition among East Asian ports in recent years in terms of limitation of this study.

Key words: international specialization, Cointegration test, competitive relationship, expansion of competition

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1. Introduction

Multinational companies established their production facilities in Asian countries as low cost clusters with prevailing international specialization strategy since 1980. This specialization significantly boosts international trade. Especially, the international specialization has been quite sophisticated in East Asia due to the gap of technology and cost between developed countries such as Japan, Korea, Taiwan and Singapore and developing countries such as China, Malaysia, Indonesia, Thailand and Vietnam. This sophistication leads a continuous growth in regional container throughput.[1]

The soaring container traffic bring a huge change in competition relationship among major ports.[2] The competition exists only among nearby ports which share the same hinterland in the past time. However, another competition has created among the ports in long distance due to vessel enlargement, intermodal logistics system, advancement of transportation technologies and change of transshipment pattern in recent years. Many studies have dealt with theoretical analysis of this phenomena in a limited scope but few studies figures out whether this trend is a sophistication of new competition or a creation of complimentary relationship. This trend has been rapidly developed in recent years but many studies are still focusing on the nearby ports and data from statistic analysis are limited.

Therefore, I would like to do an actual analysis on the expansion of competitive relationship cause by sophisticated international specialization and Chinese economic advance.[3] This study will focus on East Asian ports which have sophisticated competition and complimentary relationship.

This study choose cointegration test on time series container throughput to analyze the competitive relationship among the major East Asian ports. This test assumes that competitive relationship or complimentary relationship does exist among the target ports. A review on previous studies about international specialization and port competition will be covered in chapter 2. An analytical tool will be designed for Cointegration test in chapter 3. I will analyze the competition relationship among target ports by Cointegration test and interpret the result. Finally, I will mention the limitation of this study and suggest additional studies which are necessary.

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1 Lee, S. W., 2009. Target cargoes and biz model for Korea's port FEZ by analysis of trade among Korea, China and Japan, *The Journal of Shipping and Logistics* 25, pp.101-102.

2 Lee, S. W. and G. S. Kim, 2009. Port challenge in Northeast Asia: Korea's two-hub port strategy. In: T. E. Notteboom, P. W. DeLangen and C. Ducruet (eds.), *Portsin Proximity: Essays on Competition and Cooperation among Adjacent Seaports*, Ashgate, London.

3 "China is likely to overtake the U.S. economy in size by mid-century. And as the world's economic center of gravity shifts to Asia. U. S. preeminence will inevitably diminish" mentioned by Jeffrey D. Sachs (in U.S. Economy in Size, Fortune, Jan. 12., 2004).

2. Review of previous studies

The expansion of port competition was noticed since late 1990s. The initial study was done by Nottenboom (1997). He divided competitive relationship of European container ports into three region (Hambrug-Le Havre, Atlantic, Meditterinan) and analyze the centrality between target ports and regional ports. He mentioned that the concentration on existing ports will gradually reveal some limitation and concluded that the competitive relationship will change from competition among few major ports to competition among many regional ports. However, his study focused on centrality among major ports rather than on broad competitive relationship. In addition, his study is limited to European ports which have lower competition comparing the ports in other regions. Han (2002) studied the cargo allocation and change among 25 Asian ports by positioning analysis. He showed actual cargo loss and acquisition focusing on Busan port and proposed that convenience, connectivity and priority of cost are the competitive factors. However, his analysis is based not on transshipment traffic which is the main international competitive factor but on total cargo traffic. Thus, his study is limited to show the competitive relationship among countries. On the other hand, KIM (2009) studied how to strengthen the competitiveness of Busan port by analyzing the competitive relationship among East Asian ports. He also derived a competitive factor by analysing the seasonal centrality and competition among East Asian ports. However, he still did not analyze transshipment throughput but total throughput and included some ports which don't have any transshipment function. Afterwards, Drucret (2009) analyzed competition relationship and change in the regional status based on vessel traffic analysis but couldn't produce the detailed result for correlations among selected ports.

Besides, there were a few studies on port competitive relationship within limited region such as Strategy Positioning Analysis by Haezendonck (2001) which focused on the competitiveness of Antwerp, Competition Relationship Analysis on Pearl River Delta ports by Slack & Wang (2003), Analysis of reasonable factors to dominate in competitive relationship among the ports which share the same hinterlands by Haezendonck & Notteboom (2002). However, most studies dealt with competitive relationship within a limited region and the relationship among the ports with the same hinterland. Therefore, these studies are also quite limited to explain the geographic expansion of competitive relationship.

This study started from the weakness of existing studies. I will analyze the competitive relationship among ports in long distance and study the phenomena of wide expansion of competitive relationship. This study will use an analyzing tool by W.Y.Yap & J.S.Lam (2006) which analyzed the competitive relationship and competitive factors of East Asian major ports (Hong Kong, Busan, Kaoshiung) excluding China ports. They derived Busan and Hong Kong as competitive ports and analyzed corelation between the cargoes originated from China and neighbouring ports.

3. Design of analysing tool

3.1 Data for analysis

The target ports should have enough throughput and should compete each other for cointegration test. Many years of time series data should be secured to strengthen the validity of statistic analysis. Therefore, I selected the East Asian ports which handles more than 100 million TEUs provided by Containerisation International Yearbook (2007)[4] but I excluded a few ports such as Gwangyang port which cannot provide time series data due to the short operation period.

Table 1. Target ports

Classification	Korea	China	Japan	Taiwan
Port	Busan, Incheon	Shanghai, Tianjin, Dalian, HK, Qingdao	Kobe, Tokyo, Yokohama, Osaka	Kaoshiung, Keelung, Taichung
Quantity (Total 14)	2	5	4	3

This study uses the annual container throughput (TEU) per port from CI Yearbook and the analysis period is from 1980 to 2006. In case of Qingdao the period is from 1982 to 2006 considering the commencement of the port. All data was converted to natural log figure for convenience.

3.2 Understanding of Cointegration

If non-stationary time series variables are in the following relationship, Cointergration exist among the variables.

$$a_1 y_{1,t} + a_2 y_{2,t} = z_t \sim I(0) \quad (1)$$

if, $y_{1,t} \sim I(1)$
$y_{2,t} \sim I(1)$

The two variables with common stochastic trend made non-stationary time series. If the two variables have common stochastic trend, they are balanced. If the signs of a_1 and a_2 are same in the cointegration formular (1), the signs of $y_{1,t}$ and $y_{2,t}$ should be

4 CI Yearbook is used as an worldwide reliable source in port and logistics (Source: Yap *et al*., 2006).

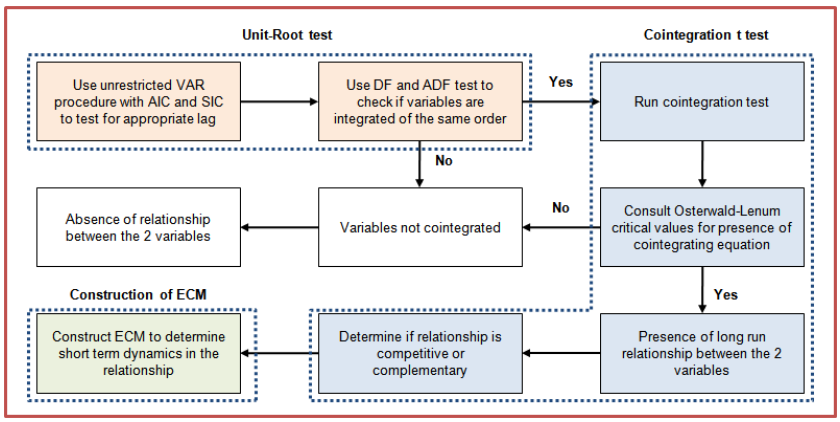
different to maintain a constant z_t. If the signs are different, the signs of $y_{1,t}$ and $y_{2,t}$ should be same.

If we apply this to competitive relationship among ports, the first one shows two ports are in competition and the later shows that two ports are complementary. W. Y. Yap & J. S. L. Lam (2006) decided the competitive relationship by this cointegration test.

3.3 Method of analysis

W. Y. Yap & J. S. L. Lam (2006) proposed a cointegration test method to check the competitive relationship by time series throughput per port.[5] This is an advanced study comparing their pervious study of W. Y. Yap & J. S. L. Lam (2004), which conceptualize the port relationship as competition and complement. In this study, they use cointegration test to check the long-term relationship between two time series data.[6] If cointegration relationship does not exist, the two data don't have long-term relationship and arbitrarily change.

Based on this theoretical background which is provided in figure 1, this study distinguishes the existence of time-series unit roots as shown in the figure. Then, this study derives the long-term relationship and apply Vector Error Correction to analyze the short-term trend. I analyzed the cointegration relationship on annual throughput of each port.



Source : Modified from Yap, W.Y. & Lam, J.S.L., (2006), p.41

Figure 1. Process of Cointegration test in port competitive relationship

5 Son (2008) applied this concept to East Asian and European Ports, respectively in order to find the relationship among container ports in long distance.

6 Cointegration refers to a linear combination of non-stationary variables. Theoretically, it is quite possible that nonlinear long-run relationships exist among a set of integrated variables. (Source: Walter Enders, Applied Econometric Time Series, 1995, p.358).

4. Empirical analysis

4.1 Analysis of competition relationship

4.1.1 Unit-Root test

This study uses the time-series throughput data of 14 East Asian ports. First, It does Unit-Root test because cointegration test is only effective when two variables are non-stationary. This study uses Augmented Dickey-Fuller Test[7] for Unit-Root test. I assumes that trend and intercept do exist.[8]

This study classifies the ports into two groups upon the result of Unit-Root test. The ports I(1) which shows stable series by first difference are Group 1 and the ports I(2) which shows stable series by second difference are Group 2. Unit-Root test is basically based on 5% variance but I loosen the variance to 10% and classifies into a separate group to overcome the limitation which can arise from the analysis of port competition.[9]

Dalian, Osaka, Shanghai and Tianjin were I(0) upon Unit-Root test but their results are non-stationary after screening graph. This study arbitrarily neglects I(0) and tests again with the figures by first difference and second difference. The result is as the following Table 2.

Table 2. Result of Unit-Root test for throughput among East Asian ports

Classification	5% Variance	Group	10% Variance	Group
Busan	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Dalian	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Hong Kong	*I*(2)	Group 2-1	*I*(1)	Group 1-2
Incheon	*I*(2)	Group 2-1	*I*(2)	Group 2-2
Kaoshiung	unstable	excluded	*I*(2)	Group 2-2
Keelung	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Kobe	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Osaka	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Qingdao	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Shanghai	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Taichung	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Tianjin	*I*(2)	Group 2-1	*I*(2)	Group 2-2
Tokyo	*I*(1)	Group 1-1	*I*(1)	Group 1-2
Yokohama	*I*(1)	Group 1-1	*I*(1)	Group 1-2

7 Augmented Dickey-Fuller Test is being widely used because of the assumption that standard error in regression formula is iid is loosened.

8 I assumed this by reviewing data.

9 Group 1-1 and Group 2-1 are based on 5% Unit-Root test; Group 1-2 and Group 2-2 are 10% Unit-Root test.

4.1.2 Cointegration test

This study establishes VAR model per group and acquired the optimal time difference upon Akaike Information Criterion.[10] The maximum time difference is 6 because the size of sample is small. This study uses Johansen Test[11] for cointegration test. It testes per port and establishes VAR model and derives a cointegration formular if cointegration relationship does exist.

4.2 Analysis of competitive relationship

The result is similar with the previous studies but I could achieve competition, compliment, no relationship beyond simple competitive relationship and redirection of throughput.

The East Asian ports have complimentary relationship or no relation rather than have competitive relationship in macro-perspective. Surprisingly, Busan, Shanghai and Hong Kong are complimentary or have no relation. This reflects that Hub & Spock transshipment system is running and there is a trend of multiple transshipment system among the large ports.[12] However, the ports in Taiwan have shrunk or maintain fierce competition. This result is similar to the study of Yap, W. Y. & Lam, J. S. L. (2006) and other studies in the recent ports competition but does not reflect the trend of competition between Busan and Shanghai or between Busan and Qingdao, which is suggested by recent studies. This difference comes from the fact that I analysed the 20 years data which is a long-term.

If we see the result of 5% confidence test in Group 1-1 (Table 3), Busan is complementary to Dalian, Osaka, Qingdao, Taichung and Yokohama. This shows that Busan takes a role as a transshipment hub port against the other ports. The complementary relationship between Busan and Qingdao still exists even though the relationship become weak in recent years. However, Busan has a competitive relationship with Keelung as it does in the study of Yap, W. Y. & Lam, J. S. L. (2006) but has no relationship with Kobe, Shanghai and Tokyo. The large ports in East Asia seems to have the equal relationship caused by transshipment system change rather then competition relationship. Most ports in East Asia are complementary but Dalian competes with Taichung, Kobe competes with Qingdao and Keelung

10 Adding the possibility of serial correlation in error term to the assumptions of Dickey-Fuller Test (DF Test), we can apply the Augmented Dickey-Fuller Test (ADF Test). So ADF Test is being widely used because of the assumption is more loosened. Applying DF Test, we generally use models like $\Delta Y_t = \beta_0 + \beta_1 t + \gamma Y_{t-1} + e_t$. However applying ADF Test, we use models like the following: $\Delta Y_t = \beta_0 + \beta_1 t + \gamma Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$

11 This study uses EViews (ver 4.1) for analysis and the Cointergration test is based on Johansen Test. Unrestricted Cointegration Rank Test was done with trace statistics.

12 Jung, B. M. (2005) explained the competition relationship with a Hub&Spoke concept that single or multiple transshipment ports exist and handles cross transshipment.

competes with Qingdao, Osaka competes with Yokohama and Taichung competes with Tokyo. The results do not reflect all trends but these quite reflect the trend of Keelung, Qingdao and Osaka.

In the long-term relationship in Group 2-1, there is a competition between Incheon and Hong Kong and between Incheon and Tianjin. However, this might be a statistical error. Only the competition relationship between Incheon and Tianjin is reasonable because the direct service to Tianjin has been increased.

Table 3. Long-term elationship of Group 1-1

Port	Busan	Dalian	Kobe	Keelung	Osaka	Qingdao	Shanghai	Taichung	Tokyo	Yokohama
Busan	-		N	**C**	**Y**	**Y**	N	**Y**	N	**Y**
Dalian	-	-	N	**Y**	**Y**	**Y**	**Y**	**C**	**Y**	**Y**
Kobe	-	-	-	**Y**	N	**C**	N	N	N	N
Keelung	-	-	-	-	N	**C**	**Y**	**Y**	N	**Y**
Osaka	-	-	-	-	-	N	**Y**	**Y**	N	**C**
Qingdao	-	-	-	-	-	-	**Y**	**Y**	N	**Y**
Shanghai	-	-	-	-	-	-	-	**Y**	**Y**	N
Taichung	-	-	-	-	-	-	-	-	**C**	**Y**
Tokyo	-	-	-	-	-	-	-	-	-	N
Yokohama	-	-	-	-	-	-	-	-	-	-

Notes: N-No relationship, C-Competition, Y-Complementary

Table 4. Long-term relationship of Group 2-1

Port	Hong Kong	Incheon	Tianjin
Hong Kong	-	-	-
Incheon	Competition	-	-
Tianjin	Competition	Competition	-

The result from the analysis of Table 5 of Group 1-2 with 10% confidence interval. However, the analysis from Table 6 of Group 2-2 shows that Kaoshiung has kept to compete with Incheon and Tianjin. This reflects decreasing throughput of Kaoshiung port, resulting from competition relationship with the neighboring ports.

Overall, Busan keeps a relatively good status comparing other rival ports. This result is similar to these of W. Y. Yam & J. S. L. Lam (2006) and Drucret (2009). However, this result is estimated from the past 20 years data which doesn't reflect the most recent change. Especially, it could not explain which Busan port has recent problems and threats. On the other hands, Incheon only supports Seoul metropolitan area but it is growing as one of major ports in East Asia. In addition, I could notice that Incheon has competitive relationship with Chinese and Taiwanese ports.

Table 5. Long-term relationship of Group 1-2

Port	Busan	Dalian	Hong Kong	Kobe	Keelung	Osaka	Qingdao	Shanghai	Taichung	Tokyo	Yokohama
Busan	-	**Y**	**Y**	N	**C**	**Y**	**Y**	N	**Y**	N	**Y**
Dalian	-	-	**Y**	N	**Y**	**Y**	**Y**	**Y**	**C**	**Y**	**Y**
Hong Kong	-	-	-	**Y**	N	N	N	**Y**	**Y**	N	**Y**
Kobe	-	-	-	-	**Y**	N	**C**	N	N	N	N
Keelung	-	-	-	-	-	N	**C**	**Y**	**Y**	N	**Y**
Osaka	-	-	-	-	-	-	N	**Y**	**Y**	N	**C**
Qingdao	-	-	-	-	-	-	-	**Y**	**Y**	N	**Y**
Shanghai	-	-	-	-	-	-	-	-	**Y**	**Y**	N
Taichung	-	-	-	-	-	-	-	-	-	**C**	**Y**
Tokyo	-	-	-	-	-	-	-	-	-	-	N
Yokohama	-	-	-	-	-	-	-	-	-	-	-

Notes : N-No relationship, C-Competition, Y-Complementary

Table 6. Long-term relationship of Group 2-2

Port	Kaoshiung	Incheon	Tianjin
Kaoshiung	-	-	-
Incheon	Competition	-	-
Tianjin	Competition	Competition	-

5. Conclusions

East Asia is the largest production base in the world which has advanced, middle and developing industrial structures at the same time. This strengthened international specialization in the region and created a lot of container traffic. Therefore, if the logistics network can be centered in Korea, Korea will enjoy economic profit and will secure strategic value which surpass other regions.

In this environment, Busan takes a role as a complementary port for neighboring ports during the past 20 years. In addition, recently grown Incheon port is also growing as a major port in East Asia which has a competitive relationship with Chinese and Taiwanese ports. This shows that there is a competitive relationship between Incheon and Chinese ports for Northeast Asian container traffic. Meanwhile, Busan keeps a complementary role for East Asian container throughput as a connection port between hub port and feeder port. The competitive relationship of Taiwanese ports is caused by the decreasing

container throughput and this shows the growth of Chinese Northeastern ports which were behind of Taiwanese ports.

Busan port keeps a role as a central port in East Asia as this analysis and Loo & Hook (2002)'s study showed. In addition, we could see the growth of Incheon port. This study does not show the role of Busan is threatened due to the development of Shanghai and Qingdao and other domestic ports as Kim and Kwak (2009) and Brucret (2009) pointed. As of matter of fact, the role of Busan port is weakening by the development of new container terminals in neighboring ports, increase of direct calling service, overseas exodus of Korean factories and aggressive marketing of neighboring ports.

In conclusion, a highly efficient and effective port sector in Korean ports will make a significant contribution to achieving success in the development as a logistics hub. Not only this will prove helpful in reducing the cost of gateway traffic, it will also make Korea's ports more competitive in the battle to win transshipment business within the Northeast Asian region. However, for keeping this position, they should continuously monitor the quickly changing trend and do their own strategies for overcome the obstacles.

This study seems to have a limitation of analysis on the recent trend. The long-term relationship was found by reviewing 20 years time series data but the recent trend since 2000 could not be found in this study. Therefore, more meaningful result could be produced if further research does more sophisticated analysis on short-term time series data and relationship between short-term and long-term analysis in complete ports in East Asia.

Acknowledgement

The author is grateful to Mr. H. U. Jeong for his kind and constructive help of the analysis part.

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