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# Analysis on Container Throughput and Interaction of Korea, China and Japan Hub Ports

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## ABSTRACT

The port industry in North-east Asia, as the cases of economic, cultural, industrial, diplomatic and other activities among countries shows us dynamic interaction between hub ports. Japanese hub ports such as Kobe, Yokohama, and Osaka enjoyed the preoccupation effect in the liner trades and they transshipped the containers of neighbouring countries and ports from the early 1970s. Since the late 1980s, Busan port could improve its competitiveness in handling costs and connectivity for Japanese medium and small sized regional ports, and expanded its feeder networks to Chinese Northern regional ports in 1990s. A few Chinese ports could be the transshipment hub ports in North-east Asia which menaced the hub status of Kaoshiung and Taiwanese hub port in 2000s, and it may have weakened the feeder network around Korean ports.

Through pair correlation, partial correlation, panel data, and panel regression, this study finds significant implications in clarifying interaction and interrelation among the hub ports in North-east Asia. First, the relationship among ports changes continually. Therefore, dynamic interaction among hub ports would continue in 21st century. Second, the panel data and panel regression show us that the container throughput of five hub ports are connected with each other and also have its own specific characteristics. Third, there could be lock-in-effect in port activity, which causes auto-correlation of panel data. Finally, the fluctuation of container throughput of hub ports is affected mainly by trade amount and less by berth length.

**Keywords :** North-east Asia, hub port, interaction, panel regression
Journal of Economic Literature classification: Q2, O1, R3

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# 1. Introduction

North-east Asian countries, composed of South Korea, China, Japan, Taiwan, East region of Russia and North Korea, show us dynamic interaction of economic, cultural, industrial, diplomatic and other activities among the countries. In port industry, after the containerisation of commercial shipping from the 1960s the status of ports in the region has been changed incessantly. Kobe port, as an early bird of container terminal operation, had enjoyed the preoccupation effect in the liner trades and handled transhipment containers of neighbouring countries and ports from 1970s to 1980s. In the late 1980s, Busan port could improve its competitiveness of handling costs and connectivity for Japanese medium and small sized regional ports due to lower stevedoring costs and feeder costs between Busan and Japanese ports other than Kobe (Kim, 2001). Since the late 1980s, Busan port transferred and expanded its feeder networks to Japanese and Chinese ports in order to collect transshipment containers. Also in 1990s, the port of Shanghai attained the hub status and recorded higher rate of increase in container throughput. These dynamic phenomena in the port industry of North-east Asia countries implicate that the status of ports is under continual threat and opportunity from competition and cooperation.

In the literature of container port, there are several papers on interaction of the container ports in North-east Asia. These papers are focused on competition and cooperation among container ports (Song, 2002; Yap and Lam, 2006; Anderson et al., 2008; Ishi et al., 2013). However, the definition and clarification of interrelation among regional hub ports or regional ports seems to be quite complicated and difficult to find proper answer (Lam and Yap, 2011). Also the volatile tendency of shipping activity connecting ports makes it complex to define the interrelation between ports.

The analysis of interaction among hub ports in North-east Asia was scrutinised with time series or cross sectional data, rarely with panel data (Chang, 2000; Ha, 2003; Anderson et al., 2008; Low et al., 2009; Lam and Yap, 2011; Ishi et al., 2013). Differently from the previous papers on interaction among hub ports in North-east Asia, this paper builds a panel data set of the five major ports in the region: Busan, Shanghai, Tianjin, Hong Kong and Kobe.

**Table 1**. Summary of literature review on interaction among hub ports

| Author | Subject | Data | Methodology |
|---|---|---|---|
| Chang(2000) | Effect of disaster on port competition | Time series (1994-1997) | Literature review |
| Ha(2003) | Comparison of service quality | Cross-section | Comparative analysis by interview and questionnaire |
| Anderson et al.(2008) | Competition between Busan and Shanghai | Time series | Game-theory |
| Low at al.(2009) | Assessment of hub status | Cross-section | Evaluation of shipping networks |
| Lam and Yap(2011) | Hub status | Time series (1996-2006) | Slot capacity calculation |
| Ishi et al.(2013) | Port competition | Time series (1990-2008) | Game-theory |

**Source** : Author's elaboration.

On the premise that container throughput of a container port depends on its handling capacity and trade amounts of the country which the port belongs to and the other neighbouring countries, this paper aims to clarify interaction and interrelation among the major hub ports in North-east Asia. In addition, through the panel regression this paper examines whether the container throughputs of five hub ports are connected with each other and also have its own specific characteristics. Since the expansionary development strategy of container facilities in a port would cause competition for attracting transshipment containers from neighbouring areas, this tries to trace the development trends of the port.

The next section of this paper reviews the policy background of container port and liner shipping. The three main countries in North-east Asia, Korea, China and Japan have their own respective policy and strategy on port and shipping industries. In addition, the bilateral shipping agreements between the three countries change the interrelation and develop the interaction between the ports in the region. The section three describes the data collection on port facilities such as berth length and container throughput of the main hub ports, and addresses correlation analysis, using pair and partial correlations. The section three also presents panel regression using the panel data which combines the data of cross sectional and time series. In panel regression this study examines the statistic characteristics of panel data and models. The section four concluded this study and suggests further studies. This study would implicate the understanding of port competition of North-east Asia in 21st century.

# 2. Interrelation among hub ports in the region

## *2.1 Background*

This study reviews serially the policy background of port and shipping in Korea, China and Japan. The development plan of container port in Korea started as a part of economic policy (Kim et al., 2009). The Korean government has established Five Years' Economic Development Plan from 1962. During the Fourth Five Years' Economic Development Plan (1977-1981), the Korean government built the container terminal at Berth 5 in Busan. In Korea, the central government constructed and managed container terminals till 1989. In 1989, the central government organized the Korea Container Terminal Authority (KCTA) which built and managed container terminals in Korea from 1989 to 2003. The Korean government introduced the Port Basic Plan on the basis of the law in 1995. The Busan Port Authority was established. in 2003; the Incheon Port Authority was formed in 2005; and the Yeosu-Gwangyang Port Authority was registered in 2011. The Korean government adjusts each development plan of container terminals through the Port Basic Plan.

After inauguration of the Open Door Policy in 1978, the government and the Communist Party of China tried to encourage trade and reform state owned enterprises. Nevertheless, the port industry remained in the condition of vertical integration and central control by the government till 1984 (Cullinane and Wang, 2007). The Ministry of Communication, the owner of ports, managed all activities and decision making. In 1984, the Chinese government began to decentralise the governance of port activities by introducing first joint management system of the central government and the Tianjin municipal government in Tianjin port (China Port Magazine, 1998; Cullinane and Wang, 2007). On the basis of successful operation of Tianjin port, the central government enlarged its policy of decentralization of port operation. In 1987, the municipal government attained the autonomous power on management of all ports except the port of Qinhuangdao (China Port Magazine, 1998; Cullinane and Wang, 2007). Also the foreign direct investment in port industry was introduced in 1987. The Chinese government established the Port Law and the Rules of Port Operation and Management in 2004. The Rules of Port Operation and Management divided the port authority in China into a port administration bureau and a port business enterprise.

In Japan, although the Japanese government adjusts each development plan of container terminals through implementing the Port Restructuring Plan and controlling the amounts of public bond of municipalities for constructing port facilities (Tsumori, 1998), container terminals have been built and managed by the local public enterprises such as the Tokyo Port Management Corp. and the Kobe Port Management Corp.. The Japanese government has tried to enhance the status of Japanese main ports by introducing reform schemes in port industry such as working hour extension and integration of operation among Japanese ports.

The bilateral shipping agreement between Korea and China was concluded in 1993 and the liner routes have been in service from 1989 (Baik and Park, 2002). The liner routes between Korea and Japan is traditional liner services which were started in the early 1950s. However, the bilateral shipping agreement between Korea and Japan is not concluded but both parties established the Korea-Japan Shipping Working Committee in 1987 (Baik and Park, 2002). The participation of Japanese liners into Korea-Japan liner routes was not allowed till 1995. The market was opened to Japanese lines from 1996 (Baik and Park, 2002). The shipping routes by bulk vessels between Shanghai and Japanese ports were opened in 1978 and the liner routes of full container vessels between China and Japan were launched in 1980 (Wang and Ducruet, 2012).

## *2.2 Construction and operation of container terminals*

In 1970s, Japanese ports are the leaders of development of container terminal in North-East Asia. Kobe port opened the container terminal in 1970, following the operation of container terminals at Yokohama and Osaka in 1969 in Japan (Japan Port Association; Japan Maritime Promotion Association, 1984).

In 1979, Busan port opened its first container terminal at Berth 5. At the beginning of containerisation in the late 1960s and in the early 1970s, Korea, China and Japan developed a few major container ports. The Korean government also underlined the concentration of container handling capacity at the two ports: Busan and Incheon in the early 1970s. Although the Korea government decided to disperse the handling capacity of Busan into Gwangyang in 1985, the government had built the container terminals mainly at Busan port till the late 1990s. In 1995, on the process of construction of Gwangyang container terminals, the earthquake at Kobe occurred. This disaster at Kobe caused Busan port to handle twice the volume of its optimum capacity (Park et al., 2006). In order to lessen the congestion around Busan port, the Korean government finalized the Busan New Port Plan in 1996.

Till the early 1980s, the major container ports in China were Shanghai, Huangpu, Tianjin, and Qingdao which handled 33 thousand TEUs in 1979 (Informa UK, 1981). Expansion of port facility was focused on these four ports and Dalian port in 1980s. The port of Tianjin commenced the container terminal, constructed by Chinese technology in 1981. In addition from 1990s the Chinese government designated serially as an international shipping center Shanghai port in 1996, Dalian port in 2003, and Tianjin port in 2006 (IAPH and China ports and Harbours Association, 2008). The Shanghai municipal government and the Chinese government completed their basic study on the development of the Yangshan New Port Plan which aimed to make Shanghai port as a logistics hub in 1997. The Chinese government announced in 2001 that the Yangshan New Port would be completed in 2005.

The operation of Yangshan New Port in Shanghai promoted competition among hub ports in North-east Asia for catchment of transshipment containers. Busan port has collected transshipment containers mainly from China and Japan. Since the Yangshan New Port and other hub ports at Northern region in China have tried to gather transshipment containers from the Northern regions of China, Busan port was facing a decresing growth ratio of transshipment containers from other countries. Hence in 21st century Korean, Chinese and Japanese hub ports compete for the containers of China's Northen region (Ha, 2003; Notteboom, 2006).

Japan also concentrated the container facilities on the major ports: Kobe, Osaka, Yokohama, and Tokyo in 1970s. The Japanese government established and implemented the Port Restructuring Plan every five years from 1961(Ministry of Transportation, 1994). At the seventh Port Restructuring Plan from 1986 to 1990 and the eighth from 1991 to 1995, the Japanese government aimed to disperse the container handling capacity of the major ports into medium and small sized regional ports in order to lessen the congestion in adjacent areas of the major ports and reduce feedering costs between the regional ports and the major ports (Ministry of Transportation, 1994; Tsumori, 1998). However, in the late 1990s, the Japanese government also changed its port policy from decentralisation to centralisation of main trunk routes in a few ports.

Therefore, in 1970s and in 1980s, the liners focused their deployment of fleets at Japanese ports and Kobe port became a hub port in North-East Asia. In 1970s and in the early 1980s Busan port used the main liner routes at Japanese hub ports such as Kobe, Yokohama and Osaka through feedering between Busan and Japanese hub ports.

### *2.3 Competition and cooperation in main trunk and feeder routes*

Ports interact with all other ports through shipping networks, and have competitive and complementary relationships or share both aspects for servicing a shipping route (Yap and Lam, 2006). Therefore, the interrelation among ports is realised through shipping networks and the analysis on the interrelation has to be confined to the ports in close proximity in shipping networks, which share their own hinterlands (Yap and Lam, 2006). The shipping networks which connect other continents, regions in the other continents, and countries in the same region are decided by shipping companies which are the demanders of port activities (Zeng and Yang, 2002; Park and Medda, 2010). However, the status of a port will be classified into hierarchical order in accordance with the shipping networks which the port handles (Zeng and Yang, 2002). The ports in the same region and continent are faced with diverse aspects and combination of competition and cooperation for attracting deployments of fleets of shipping companies.

In North-east Asia, container ports continually meet with opportunity and challenges from competitors and followers, and technological changes. In 1970s and in the early 1980s, Japanese major ports such as Kobe, Tokyo, Osaka and Yokohama, and Hong Kong were leading ports (Hoshino, 2010). These ports provided neighbouring domestic and foreign ports with feeder networks for connection to global shipping networks. Regulation and deregulation on port industry from the central governments also promotes the multiple relationships among ports through changing management and operation system, modifying strategic position of each port in port industry and enlarging opportunities of foreign direct investment (Cullinane and Wang, 2007; Hoshino, 2010).

In 1980s, the dissemination of hub function of Japanese hub ports into Chinese ports and Korean ports seems to be caused by the shifts of manufacturer following the low production costs in foreign countries (Hoshino, 2010). These interrelations among ports are closely connected with economic trends, specifically the competitiveness of manufacturing industries (Hoshino, 2010). In addition, the policy reform and the Open Door Policy since 1978 promoted the export-oriented industries and the development of container system in China (Wang and Ducruet , 2012).

In 1990s, Busan port was the most successful newcomer to vie for Chinese and Japanese traffic due to cost-competitive and efficient strategies (Tsumori, 1998; Kim, 2001; Yap and Lam, 2006). In 2000s, a few Chinese ports could be transshipment hub ports in North-east Asia, menace the hub status of Kaoshiung, Taiwanese hub port, and weakened feeder network around Korean ports (Yeo et al., 2008; Lam and Yap, 2011). For example, the increase of international transshipment containers in Shanghai port will strengthen the coastal shipping activities along the coast of China (Wang and Ducruet, 2012). In 2000s, Chinese ports also meet with competition with the Chinese ports which have the same hinterlands (Li and Oh, 2010; Lam and Yap, 2011).

# 3. Correlation analysis and panel regression

## *3.1 Data collection and summary*

### **3.1.1** Data collection

The main sources of this study’s data is from Containerisation International Yearbook online and C-i online, its internet version. The Containerisation International Yearbook informs us records of specification of each container port and terminal such as container throughput, berth length and depth, area of container yards, and calling liners. The C-i online provides us with the information of container throughput of each port in time series from 1970 to 2011.

This study also uses the data of Chinese ports in the Chinese Foreign Trade Ports by the People's Transportation Press Co., which includes container handling, construction history, and management and operation of each Chinese port. The statistics books, published by the Japan Port Association and the Ministry of Construction and Transportation of Japan, provide us with the information on development and operation of Japanese container ports and terminals.

International Monetary Fund (IMF) provides data on World export, and export and import of each country. Because this study cannot find any data sources of trade amounts within containers of each country, this study uses the export amounts of the World, Korea, China and Japan.

The five ports are selected as representative ports among hub ports in each country. This paper chooses the five ports in accordance with the following procedure. First, we search an available dataset of container ports in North-east Asia. This paper could build the panel data of container ports North-east Asia from the datasets of C-i online and Containerisation International Yearbook. However, in 1970s, the records of container ports in North-east Asia include only Korean, Japanese and Taiwan ports. In the early 1980s the records illustrate a few of Korean, Japanese and Chinese ports: Busan, Incheon, Kobe, Osaka, Yokohama, Tokyo, Shimiz, Nagoya, Shanghai and Tianjin. Among these ports, this paper assembles mainly the hub ports in competition with Busan, and the representative ports in each country: Busan, Kobe, Shanghai, Tianjin, and Hong Kong port. Especially Kobe port was a main port in North-east Asia from 1970s to 1980s. It provided Busan port with feeder and hub networks at that period. The interrelation between Busan port and Kobe port shows us a dynamic transition in feeder and hub networks in North-east Asia.

#### **3.1.2** Building panel data

This paper builds a panel data of the five ports from 1982 to 2010. A panel data is combination of time series and cross-section data, survey over time in the same cross sectional unit (Gujarati, 2003). The inputs of five ports in handling containers are certain resources: employees, equipment and provisions, electricity, area, depth and length of berth, and information technology. However collectable data of the inputs from 1982 to 2010 is strictly limited to number of quay cranes and length of berth. Though the quay cranes affect the productivity of a port and a container terminal, the calculation of handling capacity of a quay crane is quite complicate and needs lots of time. Therefore this study adopts length of berth as a representative indicator of inputs of a container port.

The outputs of a container port include number of calling vessels, tonnage of cargoes, revenues, profits, and container throughput. Among these outputs, collectable datum is restricted to the record of container throughput in C-i online and

Containerisation International Yearbook. Generally a container terminal in a port tends to design the proposed factors of productivity and service quality which considers the interrelation between inputs and outputs (Ha, 2003; Choi and Ha, 2005)

In respect of demand side of container movement in North-east Asia, the amounts of foreign trade will be a good macroeconomic variable which decides the amounts of cargo flow in the region. In addition the trade amount also is affected by the economic indicators such as GDP of partner countries, distance from export country to partner countries, and per capita GDP of partner countries, common borders with partner countries, density of transport infrastructure in partner countries (Limao and Venables, 2001; Ferrari et al, 2011; Park, 2012). Nevertheless, this study would stress the examination of effects from trade fluctuation in North-east Asia on container throughputs in the five major ports.

### **3.1.3** Summary of panel data

Since the container throughput data of Chinese ports in C-i online have been recorded since 1982, this study collects time series data from 1982 to 2010. Tianjin port handled 41 thousand TEU at minimum record among the five major ports in 1982 and Shanghai port serviced 29,069 thousand TEU at maximum in 2010 as shown in Table 2. During the same period the world export rose from 1.7 trillion US dollar in 1982 to 16 trillion US dollar in 2010.

**Table 2**. Summary of input data

| Item | Min | Max | Mean | Standard deviation |
|---|---|---|---|---|
| Throughput (Thousand TEU) | 41 | 29,069 | 6,098 | 7,256 |
| Berth length (m) | 384 | 11,935 | 4,356 | 3,098 |
| World exports (billion US dollar) | 1,697 | 16,008 | 6,143 | 4.159 |
| Export of Korea (billion US dollar) | 21.9 | 466.4 | 156 | 126 |
| Export of China (billion US dollar) | 22.2 | 1,578.3 | 367 | 460 |
| Export of Japan (billion US dollar) | 138.4 | 782 | 408 | 178 |

**Source** : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.

The container throughput of Busan port has increased from 786 thousand TEU in 1982 to 14,194 thousand TEU in 2010. The amount of export of Korea has recorded 21.9 billion US dollar in 1982 and 466.4 billion US dollar in 2010. The container throughput of Shanghai port has increased from 66 thousand TEU to 29,069 thousand TEU in 2010 since the amount of export of China has risen widely from 22.2 billion US dollar to 1,578 billion US dollar during the same period. Kobe port has increased slightly from 1,463 thousand TEU in 1982 to 2,915 thousand TEU in 2010. The amount of export of Korea has recorded 138 billion US dollar in 1982 and 782 billion US dollar in 2010.

## *3.2 Correlation analysis*

### **3.2.1** Pair correlation

The correlation coefficients of container throughput with other variables show us mostly positive relation from 1982 to 2010 as listed in Table 3. However the coefficients of container throughput with berth length and trade amount in 1990s are lower than the other periods due to the effect from the lowering status of Kobe and shutdown of operation after the Kobe earthquake in 1995.The synchronization and globalisation of each economy and the countries in North-east Asia are considered to cause the similar correlation coefficients of World exports, trade amounts of Korea, China and Japan with container throughput.

In 1980s, the length of berth had the higher correlation with container throughputs than trades of World, Korea, China and Japan. This phenomenon may be caused by deficiency of port facility in comparison to throughput increase. In 1990s, the correlation coefficients of container throughput with other variables became lower than those in 1980s due to the shutdown of Kobe port. In 2000s, the correlation coefficients of container throughput with other variables rose slightly than those in 1990s.

**Table 3.** Correlation coefficients of container throughput with other variables

| Country/Item | Berth length (m) | World exports (billion US$) | Trade amounts of Korea (billion US$) | Trade amounts of China (billion US$) | Trade amounts of Japan (billion US$) |
|---|---|---|---|---|---|
| Total period (1982-2010) | 0.60 | 0.66 | 0.66 | 0.64 | 0.65 |
| 1980s(1982-1989) | 0.70 | 0.33 | 0.33 | 0.33 | 0.34 |
| 1990s(1990-1999) | 0.28 | 0.27 | 0.24 | 0.28 | 0.23 |
| 2000s(2000-2010) | 0.56 | 0.36 | 0.36 | 0.35 | 0.35 |

**Source** : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.
Author's elaboration based on the two data

At the level of each port, all ports except Kobe record positive high correlation coefficients of container throughput with other variables as presented in Table 4. Kobe also shows lower correlation coefficients than other ports from 1982 to 2010. Furthermore, in 1990s, Kobe presents negative correlation coefficients of container throughput with trades of World, Korea, China and Japan. The port of Hong Kong has higher correlation of container throughput with berth length in 1980s and lower in 1990s and after 2004. In 2004, the Chinese central government transferred its governance of port management to municipal governments. The decentralisation of port governance in China seems to decrease correlation coefficients of container throughput with berth length in Hong Kong after 2004 by lowering port investment in relation to the throughput increase.

**Table 4**. Correlation coefficients of container throughput with other variables

| Country/Item | | Berth length (m) | World exports (billion US$) | Trade amounts of Korea (billion US$) | Trade amounts of China (billion US$) | Trade amounts of Japan (billion US$) |
|---|---|---|---|---|---|---|
| Whole period (1982-2010) | Busan | 0.89 | 0.96 | 0.95 | 0.91 | 0.95 |
| | Shanghai | 0.98 | 0.98 | 0.98 | 0.99 | 0.93 |
| | Tianjin | 0.94 | 0.97 | 0.97 | 0.99 | 0.92 |
| | HongKong | 0.87 | 0.90 | 0.90 | 0.81 | 0.93 |
| | Kobe | 0.25 | 0.38 | 0.38 | 0.34 | 0.44 |
| 1980s (1982-1989) | Busan | 0.50 | 0.96 | 0.97 | 0.99 | 0.97 |
| | Shanghai | 0.86 | 0.94 | 0.95 | 0.99 | 0.96 |
| | Tianjin | 0.88 | 0.91 | 0.92 | 0.98 | 0.93 |
| | HongKong | 0.96 | 0.99 | 0.99 | 0.98 | 0.99 |
| | Kobe | 0.62 | 0.94 | 0.94 | 0.89 | 0.95 |
| 1990s (1990-1999) | Busan | 0.94 | 0.97 | 0.87 | 0.98 | 0.80 |
| | Shanghai | 0.85 | 0.88 | 0.75 | 0.92 | 0.66 |
| | Tianjin | - | 0.93 | 0.82 | 0.96 | 0.75 |
| | HongKong | 0.55 | 0.97 | 0.91 | 0.99 | 0.88 |
| | Kobe | -0.31 | -0.73 | -0.73 | -0.63 | -0.73 |
| 2000s (2000-2010) | Busan | 0.68 | 0.90 | 0.90 | 0.90 | 0.87 |
| | Shanghai | 0.98 | 0.98 | 0.98 | 0.98 | 0.95 |
| | Tianjin | 0.91 | 0.95 | 0.97 | 0.99 | 0.91 |
| | HongKong | 0.84 | 0.91 | 0.88 | 0.85 | 0.91 |
| | Kobe | -0.57 | 0.91 | 0.91 | 0.87 | 0.95 |
| After 2004 (2005-2010) | Busan | 0.85 | 0.91 | 0.94 | 0.91 | 0.92 |
| | Shanghai | 0.96 | 0.96 | 0.97 | 0.97 | 0.87 |
| | Tianjin | 0.93 | 0.87 | 0.93 | 0.97 | 0.75 |
| | HongKong | 0.39 | 0.72 | 0.64 | 0.50 | 0.85 |
| | Kobe | -0.64 | 0.92 | 0.90 | 0.83 | 0.97 |

**Source** : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.
Author’s elaboration based on the two data

### **3.2.2** Partial correlation

In the partial correlation analysis which measures the degree of association between two random variables, the berth length and the trade amount of each country contributes positively to the increase of container throughput of each port from 1982 to 2010 as shown in Table 5. In Busan and Shanghai the port facility symbolized in berth length leads the growth of container throughput. This seems to be caused mainly by the expansionary development. On the other hand, in Hong Kong, the trade volume of China is main source of container throughput increase. In Tianjin, the berth length and the trade amount of each country contributes positively to the increase of container throughput. Meanwhile Kobe port could enjoy the pre-occupation effects from the early 1970s to the early 1980s, but it faced challenge from other ports in 1980s and it was damaged by the Kobe Earthquake in 1995 (Chang, 2000; Shibasaki, 2005). It lost the status of hub port in North-east Asia from the mid of 1990s. Hence, Kobe port shows lower correlation coefficients than the other ports.

If we divide the period from 1982 to 2010 into the three periods: 1980-1989, 1990-1999, and 2000-2010, each period lists different characteristics of main drivers for throughput increase. In 1980s, in all ports except Hong Kong, the main propeller of throughput increase is the trade amount of each country. However in 1990s Busan could handle more throughputs due to expansion of facility and Hong Kong also did so due to expansion of facility and trade increase in China. Tianjin which did not expand its facility in 1990s recorded higher productivity due to trade increase in China. In 2000s, the main source of throughput increase in Busan, Shanghai and Kobe is the trade increase of each country. Tianjin can handle more throughputs due to both facility expansion and trade increase. In 2000s, Hong Kong shows us lower correlation of container throughput with facility expansion and trade increase. The lower correlation coefficient at Hong Kong port seems to be occurred by passive investment at Hong Kong port and expansionary investment at mainland ports.

**Table 5**. Correlation coefficients of container throughput with other variables

| Country/Item | | Berth length (m) | World exports (billion US$) | Trade amounts of each country (billion US$) |
|---|---|---|---|---|
| Total period (1982-2010) | M-1 | 0.33*** | | 0.48*** |
| | Busan | 0.73*** | | -0.05 |
| | Shanghai | 0.72*** | | 0.05 |
| | Tianjin | 0.97*** | | 0.53*** |
| | HongKong | -0.17 | | 0.58*** |
| | Kobe | 0.41 | | 0.19 |
| | M-2 | 0.05 | 0.37 | -0.16 |
| | M-3 | 0.35*** | | Korea:0.05,<br>China:-0.03 Japan: -0.03 |

| Country/Item | | Berth length (m) | World exports (billion US$) | Trade amounts of each country (billion US$) |
|---|---|---|---|---|
| 1980s (1982-1989) | Total | 0.79*** | | -0.59*** |
| | Busan | 0.41 | | 0.96*** |
| | Shanghai | 0.15 | | 0.98*** |
| | Tianjin | 0.55 | | 0.95*** |
| | HongKong | 0.11 | | 0.74 |
| | Kobe | -0.27 | | 0.93*** |
| 1990s (1990-1999) | Total | 0.56*** | | -0.51*** |
| | Busan | 0.82*** | | 0.57 |
| | Shanghai | 0.25 | | 0.67 |
| | Tianjin | - | | 0.96*** |
| | HongKong | 0.84*** | | 0.99*** |
| | Kobe | 0.15 | | -0.71** |
| 2000s (2000-2010) | Total | 0.46*** | | 0.34*** |
| | Busan | -0.39 | | 0.83*** |
| | Shanghai | 0.38 | | 0.62* |
| | Tianjin | 0.67** | | 0.97*** |
| | HongKong | 0.19 | | 0.32 |
| | Kobe | 0.01 | | 0.93*** |
| After 1997 (1998-2010) | Busan | -0.51* | | 0.87*** |
| | Shanghai | 0.14 | | 0.71*** |
| | Tianjin | 0.66 | | 0.97*** |
| | HongKong | 0.20 | | 0.27 |
| | Kobe | 0.25 | | 0.90*** |
| After 2004 (2005-2010) | Busan | -0.17 | | 0.76 |
| | Shanghai | 0.33 | | 0.64 |
| | Tianjin | 0.81 | | 0.89** |
| | HongKong | -0.12 | | 0.35 |
| | Kobe | -0.13 | | 0.95*** |

Note : *significant at 10 percent level; ** significant at 5 percent level; *** significant at 1 percent level.
Source : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.
Author's elaboration based on the two data

## 3.3 Panel regression

Before estimating coefficients of variables, we test the suitability of models by examining statistic characteristics of panel and panel models, contemporaneous correlation between data of the ports, heteroskedasticity test between data of the ports, serial auto-correlation of each port, significance test of random effects model, Hausman test of efficiency of fixed effect model and random effect model, autocorrelation of panels, and Sargan test of over-identifying restrictions in order to find out suitable models as shown in Table 6. Even though this study adopts two cases of sample: Case I includes the five ports-Busan, Shanghai, Tianjin, Hong Kong, and Kobe; Case II excludes Kobe, the statistical characteristics of Case I and II in suitability have the similar results.

**Table 6**. Summary of Searching suitable models and suitability tests

| Test/Method | Case Ⅰ | Case Ⅱ |
|---|---|---|
| Variables | Dependent: container throughput<br>Independent: berth length, amount of export and import of each country<br>Port: Busan, Shanghai, Tianjin Hong Kong, Kobe | Dependent: container throughput<br>Independent: berth length, amount of export and import of each country<br>Port: Busan, Shanghai, Tianjin Hong Kong |
| Tests for contemporaneous correlation | chi2(10) = 52,<br>Probability >chi2 = 0.0000 | chi2(6) = 23.9,<br>Probability >chi2 = 0.0005 |
| Tests for panel-level heteroskedasticity | chi2 (4) = 65<br>Probability >chi2 = 0.0000 | chi2 (4) = 110.78<br>Probability >chi2 = 0.0000 |
| Tests for serially auto-correlation in random effects model | Serial correlation:<br>LM(ρ =0)= 138<br>Probability >chi2(1) = 0.0000;<br>ALM(ρ =0)= 14,<br>Probability >chi2(1) = 0.0109<br>Joint Test:<br>LM(Var(u)=0,rho=0) = 833 Probability >chi2(2) = 0.0000 | Serial correlation:<br>LM(ρ =0)= 83.6,<br>Probability >chi2(1) = 0.0000;<br>ALM(ρ =0)= 72.09,<br>Probability >chi2(1)= 0.0000<br>Joint Test:<br>LM(Var(u)=0,rho=0) = 85 Probability >chi2(2) = 0.0000 |
| Characteristics of error term in fixed effects model | F(4.13)=72<br>probability> F = 0.000 | F(3. 74)=5.98<br>probability> F = 0.0008 |
| Significance test of random effects model | chi2(1) = 813<br>Probability > chi2 = 0.0000 | chi2(1) = 13.1<br>Probability > chi2 = 0.0003 |
| Hausman test | Probability >chi2 = 0.887 | Probability >chi2 = 0.663 |
| Auto-correlation of error term in fixed effects model & random effects model | modified Bhargava et al.<br>Durbin-Watson = 0.15 in fixed effects model | modified Bhargava et al.<br>Durbin-Watson = 0.17 in fixed effects model & random effects model |
| Sargan test of over-identifying restrictions of dynamic panel model | chi2(170) = 166,<br>Probability > chi2 = 1.000 | chi2(170) = 138.15,<br>Probability > chi2 = 1.000 |

Source : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.
Author's elaboration based on the two data.

This study adopts the following panel regression function,

$$Conit = \alpha + bi\ Berthit + ci\ Trit + ui + eit \qquad (1)$$

Where,
$Conit$ : Throughput of port i in year t
$Berthit$ : Berth length of port i in year t in meter
$Trit$ : Amount of export and import of the country in year t which port i belongs to

***Contemporaneous correlation test among panels in fixed effects model***

Tests of contemporaneous correlation in Case Ⅰ and Ⅱ conclude that there is contemporaneous correlation among panels. This seems to be affected by the trend of World trade which can change the trend of container throughput in each port.

$$Ho : Cov\ (eit\ ,\ ejt) = 0$$

***Heteroskedasticity test between panels in fixed effects model***

There is panel-level heteroskedasticity. The Modified Wald test for groupwise heteroskedasticity rejects at 1% significance the null hypothesis excluding heteroskedasticity among panels. Each port shows its respective characteristics in panel regression.

$$Ho : Var(\ eit\ ) = \sigma 2, \ \forall i \ \ i = 1, \ \cdots, \ I$$

***Auto-correlation test of error term in random effects model***

Tests for error-component model tells that in Case Ⅰ and Ⅱ there is serially auto-correlation in error term eit, under the assumption of excluding random effects. In random effects model, we could find auto-correlation in error term eit,. Adjusted Lagrangian Multiplier (ALM) shows auto-correlation in error term eit. The random effects model assumes that the individual error terms are not correlated across time series units, as shown in Equation 2 (Gujarati, 2003).

$$eit = \rho\ eit\text{-}1 + vit \qquad (2)$$

$$Ho : \rho = 0$$

***Test on characteristics of error term at fixed effects model***

In Case Ⅰ and Ⅱ the null hypothesis of that all panels do not have its own characteristics in error term ui in Equation 1 has been nullified. It means that fixed effects model is more suitable than panel generalized least squares (Panel GLS).

$$Ho : ui = 0, \ \forall i \ \ i = 1, \ \cdots, \ I$$

### *Significance test of random effects model*

Breusch and Pagan Lagrangian multiplier test for random effects concludes that in Case Ⅰ and Ⅱ the null hypothesis which variance of error term ui is naught has been rejected. Therefore, random effects model may be more suitable for estimation than pooled ordinary least squares.

$$Ho : Var( ui ) = 0, \; \mathbf{I} i \quad i = 1, \cdots., I$$

### *Hausman test of efficiency of fixed effect model and random effect model*

The hausman test does not nullify the null hypothesis. Hence there is no systematic difference between fixed effects model and random effects model, and both fixed effects model and random effects model may result consistent estimators.

$$H0 : Cy5ov(Berthit, ui ) = 0, Cov(Trit, ui ) = 0, \; \mathbf{I} i \quad i = 1, \cdots., I$$
$$H1 : Cov(Berthit, ui ) \neq 0, Cov(Trit, ui ) \neq 0, \; \mathbf{I} i \quad i = 1, \cdots., I$$

### *Auto-correlation test of error term in fixed effects model & random effects model*

Auto-correlation of error term in fixed effects model and random effects model is evaluated by modified Bhargava et al. Durbin-Watson statistics. Since the values of modified Bhargava et al. Durbin-Watson statistics are far away from 2 in the two models, the null hypothesis could be rejected and there is auto-correlation.

If there is first-order autocorrelation, we have the following equation,

$$eit = \rho \; eit\text{-}1 + vit \tag{3}$$
$$Ho : \rho = 0$$

While Equation 2 tests autocorrelation in random effects model, Equation 3 tests autocorrelation in random effects model and fixed effects model. In fixed effects model error term-eit- is not a random variable but assumed to be a parameter (Gujarati, 2003).

### *Sargan test of over-identifying restrictions*

Sargan test for over-identifying restrictions concludes that over-identifying of dynamic panel model is proper. The null hypothesis is not rejected.

The Table 7 gives us six models of panel regression: Model1-1, 1-2, and 1-3 are three models of generalized least squares; Model 2 is a fixed effects model; Model 3 is a fixed effects model with auto correlation; and Model 4 is a random effects model with auto-correlation. In all models, trade volume affects more container throughput of each port than berth length as the results of partial correlation. In East Asia, trade volume is the decisive variable for container throughput of port. Among the models of generalized least squares, Model 1-2 with heteroskedasticity and contemporaneous correlation has better t-value and Wald χ2. Model 2 of fixed effects model shows us the similar result with the result of Model 1-1, generalized least squares model with heteroskedasticity. Model 4, random effects model with autocorrelation, has slightly better R2 and F value than Model 3.

**Table 7.** Panel regression results of container throughputs of the five ports

| Variable/Model | 1-1<br>Panel GLS<br>with<br>heterosked-astic | 1-2<br>Panel GLS<br>with heteroskedastic &<br>cross sectional corr. | 1-3<br>Panel GLS<br>with<br>homoskedastic | 2<br>Fixed<br>e.m. | 3<br>AR(1),<br>fixed | 4<br>AR(1),<br>random |
|---|---|---|---|---|---|---|
| Constant | -807 | -252 | -165 | -1907 | 12803 | 2089 |
| Berth | 1.27***<br>(9.23) | 0.65***<br>(19.35) | 0.72***<br>(4.2) | 1.25***<br>(7.7) | 0.17***<br>(2.2) | 0.26***<br>(3.3) |
| Tr | 3.38***<br>(6.05) | 5.12***<br>(58.6) | 5.03***<br>(6.6) | 4.14***<br>(7.4) | 3.75***<br>(10.5) | 4.21***<br>(11.6) |
| Sample Size | 145 | 145 | 145 | 145 | 140 | 145 |
| R2<br>F<br>Wald χ2 | -<br>-<br>258.68 | -<br>-<br>7825 | -<br>-<br>146.67 | 0.49<br>237.1<br>- | 0.48<br>63.8<br>- | 0.49<br>-<br>182 |

**Note** : *significant at 10 percent level; ** significant at 5 percent level; *** significant at 1 percent level.
Source : Informa UK, Containerisation International Yearbook, each year.
IMF, International Financial Statistics Yearbook, each year.
Author’s elaboration based on the two data.

# 4. Conclusion

The port industry in North-east Asia, as the cases of economic, cultural, industrial, diplomatic and other activities among countries shows us dynamic interaction between hub ports through changeable shipping networks. Japanese hub ports such as Kobe, Yokohama, and Osaka could enjoy the preoccupation effect in the liner trades by container ships and handled trasshipment containers of neighbouring countries and ports from the early 1970s. Since the late 1980s, Busan port could improve its competitiveness of handling costs and connectivity for Japanese medium and small sized ports, and expanded its feeder networks to Chinese Northern regional ports, for example Yantai in Shandong Province and Dandong in Liaoning Province. Furthermore, the shifts of manufacturer following the low production costs in foreign countries propelled dissemination of hub function of Japanese ports into Chinese and Korean ports. Furthermore Chinese hub ports have enhanced their hub status by inducing global shipping companies and developing port facilities since 1990s.

Nevertheless, the definition and clarification of interaction and interrelation among ports are quite difficult and complex due to basic function of a port connecting to global networks through shipping services. In addition, the volatile tendency of shipping activity connecting ports makes it hard to define the interrelation between ports.

Through pair correlation, partial correlation, and panel data and panel regression, this study finds some implications in clarifying interaction and interrelation among the hub ports in North-east Asia. First, the relationship among ports changes continually. The hub status of a port keep changing and a hub port can face challenges from a feeder port and other hub ports. Therefore, this dynamic interaction among ports will exist in 21st century. Second, the panel data and panel regression show us that the container throughput of five hub ports are connected with each other and also have its own specific characteristics. The synchronization and globalisation of each economy and the countries in North-east Asia are considered to cause the similar correlation coefficients of World exports, trade amounts of Korea, China and Japan with container throughput. At the level of each port, all ports except Kobe record positive high correlation coefficients of container throughput with other variables. Kobe also shows lower correlation coefficients than other ports from 1982 to 2010. Furthermore, in 1990s, Kobe presents negative correlation coefficients of container throughput with trades of World, Korea, China and Japan. Third, there could be lock-in-effect in port activity, which causes auto-correlation of panel data. Finally, the fluctuation of container throughput of hub ports is affected mainly by trade amount and less by berth length. In all models, trade volume affects more container throughput of each port than berth length as the results of partial correlation. In East Asia, trade volume is the decisive variable for container throughput of port.

Although this study finds some implication on port activity and interaction among the five ports, some questions still remain. How much do the regulation and deregulation on port industry from the central governments and change shipping networks? How could we define the competition and corporation among ports? These questions would present us meaningful prospect to forecast the status of ports in future.

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