Local strength, global weakness:
A maritime network perspective on South Korea as Northeast Asia's logistics hub

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ABSTRACT

Port development in South Korea has taken advantage of the country's remarkable situation and economic growth during the past decades. However, the governmental 'two-hub port strategy' is currently at stake because of fierce competition from Chinese ports. Based on a global database on the daily movements of containerships, this paper proposes an evaluation of the position of South Korean ports within Northeast Asian liner networks in 1996 and 2006. Main results show that although Chinese ports have increased substantially their position in the maritime system, South Korean ports (notably Busan) still keep a dominant hub function in this region. However, a multi-scalar analysis shows the limited global radiance of South Korean ports. Implications for policy and further research are addressed.

Key Words: Asia, betweenness, centrality, hub port, liner shipping, network analysis

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1. Introduction

Specialized on agricultural activities during the Japanese occupation (1905~1945), devastated by the Korean War (1950~1953) and wrongly oriented on an import substitution strategy between 1953 and 1961, the Republic of Korea (ROK, hereafter South Korea) was at the beginning of the 1960s one of the poorest country in the World. A radical change in the national economic policy propelled its GDP at the 14th global rank in 2007. This shift started in 1961 when the government adopted an outward-looking strategy forged on a strong alliance between the Army (General Park Chung Hee ruled South Korea freom 1961~1979) and some few rich families, founders of the future *chaebols* (large Korean conglomerates). The government collected foreign grants and soft loans and through its direct control on the local banks, supported the companies which followed its national industrial plans and massively exported to developed countries such as United-States. The authorities invested also a large amount of money in social infrastructures and modern communication network guaranteeing to the conglomerates a social peace based on the repression of trade unions. In return, the ruling class beneficiated of various material advantages provided by the chaebols. Rebounding with the democratization at the end of the 1980s, the South Korean model achieved an incredible success. South Korea became member of OECD in 1996 and its industry dominated several world industries such as shipbuilding, DRAM or LCD panels.

Nevertheless, this strategy reached its limits in 1997 with the Asian financial crisis that hardly affected an economy too much depending on loans without any clear control on the corporate assets. Moreover, South Korea is not anymore a low-cost country. It is an emerged economy, showing some early signs of maturity (population getting older very quickly, delocalization of thousands factories to cheap labor countries such as China, Vietnam and India). Last but not least, South Korea is sandwiched between a high-tech advanced Japan, a booming China and a belt of under-developed states as Mongolia or the constrained North Korea (KITA, 2006). To challenge this situation, South Korea decided to improve its regional integration and to depend less on the United-States, which did not provide strong support during the 1997 crisis. South Korea should recover its historical role of bridge between China and Japan, but a role sustained by a modern and rich domestic economy, also able to be a gateway between North-East Asia and the World (Roussin, 2008). As a result, this paper will focus on this recent strategy of turning South Korea into Northeast Asia's logistics hub (Song and Lee, 2006).

More specifically, this research wishes to verify to what extent South Korea is a hub for this region. While many official reports have constantly promoted this hub strategy since the late 1980s (Yoo, 2006), a recent in-depth review of the history and rationale of the 'two-hub port policy' that is based on Busan and Gwangyang ports offers a rather pessimistic portrait about the competitiveness of South Korean ports (Lee and Kim, 2009).

Their performance in terms of traffic volume and traffic growth has lowered due to fierce competition with neighbouring Chinese ports and other local ports. For instance, Chinese ports of the Northeast provinces tend to use Qingdao instead of Busan for transhipping their cargoes. In addition, some criticism has been expressed about the true potential of the free-trade zone policy that creates huge development areas around South Korea's main ports of Incheon, Busan and Gwangyang for manufacturing and light industries (Ducruet, 2009). Such policies cannot avoid the shift of many South Korean manufacturing firms to Southeast Asia and China, resulting in less local demand for port activities (Lee and Kim, 2006). Nevertheless, South Korean ports are actively engaged in modernisation of their equipments so to keep their technological advance and solve congestion problems nearby main coastal cities (Frmont and Ducruet, 2005). It is only in the aeronautic sector that South Korea seems to increase its position, notably since the realization of Incheon's new international airport in 2001, through the successful 'Pentaport' strategy (Ducruet, 2007).

Despite the abundance and quality of recent research on Korean ports, this paper proposes a new contribution through the application of maritime network analysis. It is rather surprising that despite the rapid and profound changes occurring in the Northeast Asian port system, there is no comprehensive study of this region throughout the literature on maritime networks. More likely are studies on the Caribbean (McCalla *et al*., 2005), the Mediterranean (Cisic *et al*., 2007), the North Atlantic (Helmick, 1994) and the world (Joly, 1999; Ducruet *et al*., 2008a). Other studies have focused on its neighbour North Korea, showing that South Korea has actually become North Korea's main hub in recent years (Ducruet, 2008; Ducruet *et al*., 2008b). Approaching South Korea's hub position through the structure of connected maritime networks is relevant since 99% of its international trade volume is seaborne. The research hypothesizes that although South Korean ports have lost their position to Chinese ports in terms of total throughput, their relative position as hubs may have been maintained-or may even have been strengthened. A research based on network analysis would complement the literature on East Asian containerisation dynamics in which South Korean ports have been largely neglected compared with China, Taiwan, Japan and other ports (Comtois, 1994; Robinson, 1998; Comtois, 1999; Rimmer and Comtois, 2005; Notteboom, 2006a; Yap *et al*., 2006).

The remainders of the paper are as follows. Section 2 introduces the source and methodology for a network analysis of liner shipping networks, together with some preliminary outcomes based on the data. Section 3 presents the main results of the network analysis applied to Northeast Asia.[2] Finally, section 4 proposes some implications of this study for South Korean port policy and further research.

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2 The software used in this paper was created by Laboratoire Bordelais de Recherche en Informatique (LABRI), was initially created for biology. It is today extensively used for social network analysis and in transport studies notably on air transport netwoks, intra and inter-urban commuter flows and multinational corporations' networks in the SPANGEO progect (http://s4. parisgeo.cnrs.fr/spangeo/spangeo11.htm). The TULIP software is free, opensource and available at: http://tulip.labri.fr/

2. Source and methodology for network analysis

2.1 A global database on vessel movements

Two main databases exist for analyzing the structure of liner shipping networks. First, Containerisation International provides annual yearbooks describing the service schedules of the world's main shipping lines. It contains information on vessels (capacity in TEUs), together with the carrier's name and on the service itself (sequence of ports and periodicity). Although it has the advantage of being reliable and financially accessible, its main problems are the absence of numerous companies and the probable difference between theory (service offered) and practice (true circulation).

For such reasons this research has selected another source: Lloyd's global database on vessel movements. Compared to the other source, data from Lloyd's Marine Intelligence Unit (LMIU) is based on the effective movements of vessels and concentrates about 98% of the world fleet of fully cellular containerships. Data for this research has been extracted for two years (1996 and 2006) and is limited to one month per year (i.e. October) because liner services are relatively constant throughout the year despite seasonal effects.

Although there is no consensual geographical definition of Northeast Asia, this paper includes all Chinese, Japanese, South Korean, Taiwanese and Far-East Russian ports in the analysis. Direct linkages between those ports constitute the architecture basing the analysis of the Northeast Asian liner network. This constitutes in itself a necessary simplification of the reality of liner shipping. While a line-bundling service calls at multiple ports through rotations of vessels and spatial continuum of the sequence, this research chooses to segment the services into a graph of distinct links. In addition, it mixes together intra and extra-Northeast Asian services. It is a binary approach to the network: there is or is not a connection between two ports within a given period of time. For instance, the Busan-Kobe connection is included in the graph regardless of the overlapping of successive (or even simultaneous) services, should they be different either in terms of scale (intra or extra) or function (line-bundling or feedering). Every link can be weighted by various measures such as:

- *Hierarchy*: total traffic (sum of all vessel capacities), number of movements, vessels, companies;
- *Density*: total traffic divided by number of vessels, movements, companies, but also frequency (e.g. movements per week).

The same applies to ports, with the possibility to use graph theory to calculate the relative position of the ports in the network. While some simple indicators may be calculated manually, such as the number of connections (i.e. maritime degree) or the traffic

distribution among those connections (e.g. concentration measures such as hub dependence),[3] specific software is necessary to calculate the "centrality" of the ports. In this paper, we limit such possibility to the calculation of the so-called "betweeness centrality": it corresponds to the number of shortest paths within the graph on which a node (i.e. port) is located. When it comes to ports and maritime transport, such measure is more likely to describe port's maritime accessibility or "intermediacy". Intermediacy as defined by Fleming and Hayuth (1994) corresponds to the level of insertion of a transportation hub within carriers' networks. It is a vital component of "centrality" that is the situation of a port with regard to markets and hinterlands. In order to match the concept of intermediacy with the measure of betweeness centrality, we decide to use the term "betweeness" that accounts for the equivalent and more classical concept of "in-betweeness".

2.2 Preliminary outcomes

The first approach to understanding the position of ports is the classical map of individual port traffic (Fig. 1). Although it does not account for their relative position, it gives an indirect but accurate idea of this position, because traffic volume in itself synthesizes a myriad of dynamics within and between ports.

There is a striking contrast in terms of growth between a group of large Chinese ports with fast growth and main Japanese and Taiwanese ports with slow growth. Ningbo, Xiamen and Shenzhen in China generate important traffic volumes and a rapid growth while in Japan, only small ports exhibit rapid growth, as seen in a number of developed countries where bigger ports enjoy lower growth rates on average (Lemarchand and Joly, 2009), as seen with the process of port de-concentration observed in the US for instance (Notteboom, 2006b).

Before analyzing the network per se, one interesting study is the comparison of the weight of the main inter-port links (Table 1).

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3 Hub dependence of a port is defined by Ducruet (2008) as the share of the biggest connection in total traffic. High values (e.g. above 50%) indicate a weakness while low values (e.g. below 50%) reveal a strong position towards immediate neighbours/competitors. Other measures may be applied to the distribution of traffic among a port's connections, such as entropy and Gini coefficient.
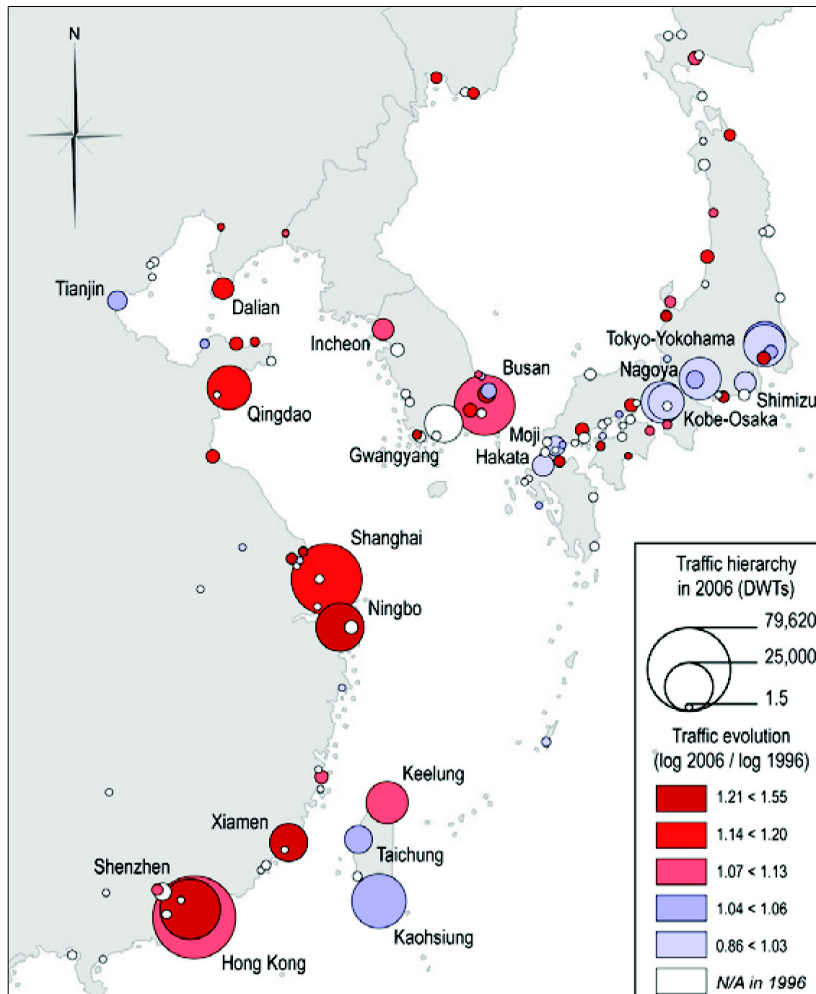
Figure 1. Liner traffic hierarchy and evolution at Northeast Asian ports, 1996~2006

The top connections reveal that connections among Chinese ports have superseded connections among Japanese ports, although in reality the Kobe-Nagoya connection has remained stable in terms of total capacity circulated. Although the growth of Chinese ports is often seen as a threat, we see that Busan has increased its rank in the table from 6th to 5th thanks to its strong connection with Shanghai. However, Busan appears only once in 2006 while it appeared two times in 1996 through the connections with Hong Kong and Kaohsiung. Hong Kong keeps its dominant position, notably with the Kaohsiung connection, but also with Shenzhen, Shanghai and Ningbo. Intra-Japan connections are now lagging behind intra-China connections in terms of total traffic volumes.

Table 1. Top 10 direct inter-port connections, 1996~2006

(Unit: DWT)

Rank	1996			2006		
	Port 1	Port 2	Traffic	Port 1	Port 2	Traffic
1	Hong Kong	Kaohsiung	10,940,760	Shenzhen	Hong Kong	27,536,943
2	Kobe	Nagoya	4,063,842	Kaohsiung	Hong Kong	14,554,136
3	Nagoya	Yokohama	3,246,985	Shanghai	Ningbo	12,552,982
4	Kobe	Kaohsiung	3,169,702	Shanghai	Hong Kong	8,957,273
5	Kobe	Yokohama	2,835,675	Shanghai	Busan	8,616,047
6	Hong Kong	Busan	2,387,515	Ningbo	Hong Kong	6,385,765
7	Hong Kong	Kobe	2,273,124	Shenzhen	Shanghai	5,552,308
8	Busan	Kaohsiung	2,227,229	Shanghai	Qingdao	5,448,910
9	Osaka	Tokyo	2,081,384	Xiamen	Hong Kong	5,161,566
10	Nagoya	Tokyo	1,912,021	Nagoya	Kobe	4,832,798

3. The maritime betweeness of South Korean ports

3.1 Betweenness and the port hierarchy

Another possible approach is to compare the number of direct connections with the hub centrality index[4] (Fig. 2). At both years, we see that Busan has the biggest number of connections (44 and 77 respectively)[5] and a high level of hub centrality. It clearly confirms its position as a hub, i.e. connecting a wide range of other ports with a relatively even distribution of traffic among its relations. In general, there is a good relation between the two indicators: the more connections, the stronger the position in the network.

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4 This index is the inverse of hub dependence index, which corresponds to the share of the main connection in total traffic. The higher the hub centrality index, the stronger is the port vis-vis its immediate competitors.

5 A recent survey on Busan's feeder services counts a total of 110 ports connected (Armbruster, 2005). The difference with the number of direct links in 2006 is explained by the inclusion of non-direct links in the total of 110.
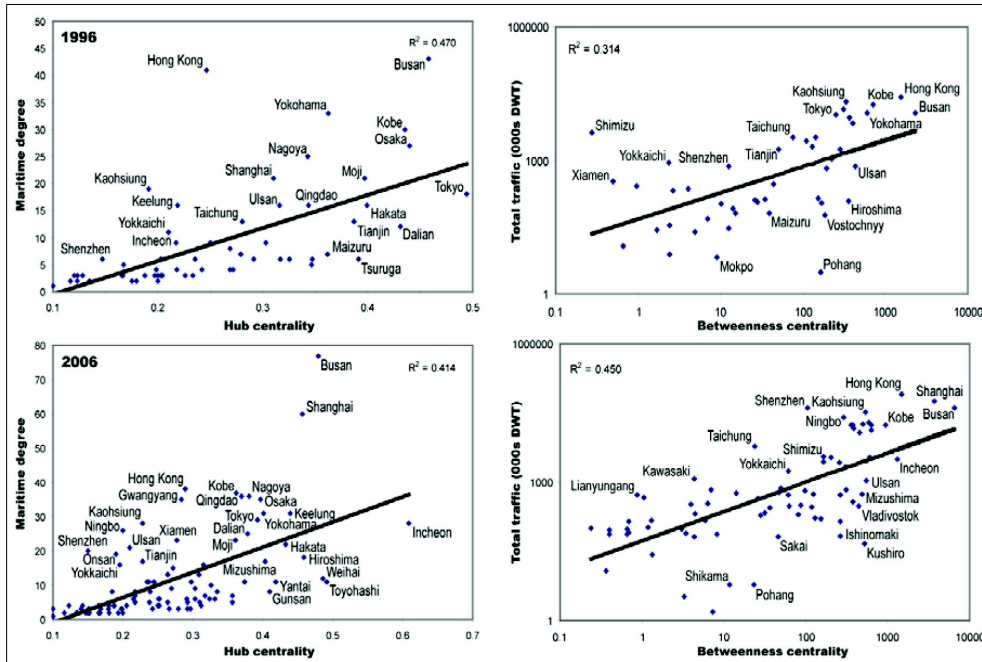
Figure 2. Connection characteristics of Northeast Asian ports, 1996~2006

Some local specificity may alter the pattern. For instance, Shenzhen has increased its array of connections but it remains dependent on Hong Kong for more than 60% of its traffic, despite the development of direct calls from global shipping lines since the late 1990s (Wang, 1998). The same applies to Kaohsiung (Taiwan) that doubled its degree from 19 to 28 but kept a strong relation with Hong Kong (i.e. from 52% to 42% of its traffic) due to the geopolitical issue with mainland China (Comtois and Wang, 2003). The evolution of these indicators also reflects the impact of port policies: Incheon, Shanghai and Ningbo have tripled their connections, but while this has resulted in a higher hub centrality (0.22 to 0.61) and lower hub dependence (46% to 16%) in Incheon and Shanghai (0.31 to 0.46; 32% to 22%); hub centrality has reduced for Ningbo (0.30 to 0.20). Although Ningbo has successfully and rapidly developed as a rival to Shanghai (Cullinane *et al*., 2005), its growth remains dependent on the latter in terms of maritime network design. The same factor explains the profile of Gwangyang: non-existent as a container port in 1996, it deploys 35 connections in 2006 but more than 35% goes through Busan as an effect of the two-hub port system, resulting in a lower hub centrality (0.28) than its size would predict. Such dynamics suggest that the growth of secondary ports in the vicinity of load centres is possible only through a stage of hub dependence, as seen for Shenzhen, Ningbo, Incheon and Gwangyang.

Therefore, geographical proximity is one important factor in port development,

because it conditions the degree to which a given port can reach a stage of maturity and independence. Of course, geographical location is not enough explaining port hierarchies: more likely is the port selection process by shipping lines combined with national and local port policies (Slack and Wang, 2002). For older ports such as the main Japanese ports, the connections have remained quite stable between 1996 and 2006.

In terms of betweenness centrality compared with total traffic, Busan is the most central port in the whole regional network at both years and one can differentiate ports with higher traffic than centrality (e.g. Shenzhen, Yokkaichi and Kaohsiung) from the opposite profile where centrality is higher than traffic volume (e.g. Pohang, Ulsan, Far-East Russian ports and Incheon in 2006). The interplay between network position and port performance is illustrated by the fact that bigger ports have also the best betweenness: Busan, Hong Kong, Kobe, Yokohama, Shanghai and Osaka. Yet, large Japanese ports tend to be less central in the network compared with their traffic size.

3.2 Structure and dynamic of Northeast Asian liner networks

The visualization of the entire graph of liner networks in 1996 and 2006 allows for a clear overview of the network structure and port hierarchy (Fig. 3 and Fig. 4). The size of ports and inter-port links corresponds to betweeness centrality measures, while the country of belonging is also illustrated by a colour for better readability. Each graph is built regardless of the true geographical location of the ports; instead, distance between them is automatically generated depending on their relative betweenness in the network. Such methodology allows verifying i) which ports dominate the system and ii) the existence of coherent groups of ports well interconnected.

In 1996, the dominance of Busan among other ports is made evident. The liner system is a two-headed network based on Busan and Hong Kong. Each port possesses its own privileged relations with other Northeast Asian ports, based on either geographical or functional proximities. Busan polarizes a majority of Japanese ports, together with most South Korean ports (except Masan), Russian ports, Taichung and Keelung in Taiwan, Fuzhou and Dandong in China. The influence of Busan over Japanese ports is stronger for smaller ports in general (except for Nagoya and Hiroshima), with a preference for ports located at specific locations such as Northwest coasts of Japan (e.g. Sakata, Tomakomai, Kanazawa, Tsuruga, Niigata and Fushiki), the Kanmon Straits between Kyushu and Chigoku (e.g. Yawata, Ube and Oita) and Ehime island (e.g. Imabari, Komatsushima and Matsuyama). These ports have in common not to be well suited technically and geographically for welcoming the direct calls of global shipping lines. Thus, a majority of Chinese and other Japanese ports are more polarized by Hong Kong while exerting their influence upon their own sub-system. Notably, large ports such as Tokyo, Kobe and Yokohama (Japan), Shanghai, Qingdao and Dalian (China) and Kaohsiung tend to be less
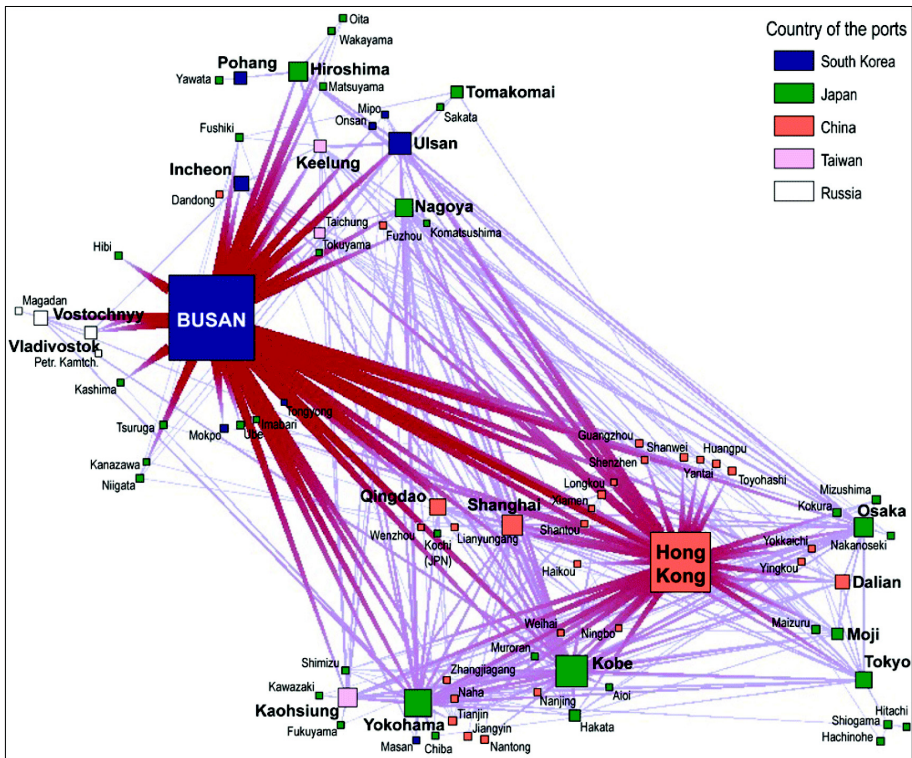
Figure 3. Liner networks within Northeast Asia, 1996

under Busan's polarization, probably because they also connect to Hong Kong and to a variety of ports outside Busan.

In 2006, the overall structure is very similar to the one of 1996, except that Shanghai has superseded Hong Kong at the second rank of betweenness and there is a greater complexity in the network. Busan has still a clear dominance over all Northeast Asian ports. While it has a wide array of dependent ports as in 1996, mostly Japanese and Russian, other South Korean ports tend to have shifted under the control of another hub. Only Incheon and Gwangyang have developed their betweenness to the point of polarizing a number of Chinese Yellow Sea ports (e.g. Rizhao, Qinhuangdao, Tangshan and Longkou). The geographical coverage of Busan's polarization on Japanese ports has remained rather stable: those are mostly smaller ports and they locate for a large part on the Northwest coasts of Japan, where big containerships do not anchor due to remoteness, spatial scattering, lack of nautical accessibility and to avoid deviation from the main trunk line (Zohil and Prijon, 1999). In fact, other ports are polarized by other hubs, either due to simple geographical proximity (e.g. Chinese ports and Shanghai, Hong Kong; Yokohama and Kawasaki), or to the more complex factor of service coverage by shipping lines. Due to the mixture of so many services of different kind in the analysis, it is not easy to identify

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with precision which service or which company causes the grouping of some geographically distant ports. A myriad of random forces also cause the changes in the organization of shipping networks. The main common explanation is that ports having many connections outside of Busan are grouped together regardless of any geographical logic. In addition, the increased fluidity of liner shipping and the current reorganization of services in a changing economic and regional environment cannot be fully explained rationally. More interesting is the shift of some ports from the influence of certain hubs and the possible factors causing this shift. For instance, Hakata that was in the vicinity of Kobe in 1996 has gained some independence and is polarizing a variety of Yellow Sea ports in 2006. Similarly, Keelung (Taiwan) shifted from Busan's influence in 1996 to Kobe's influence in 2006.
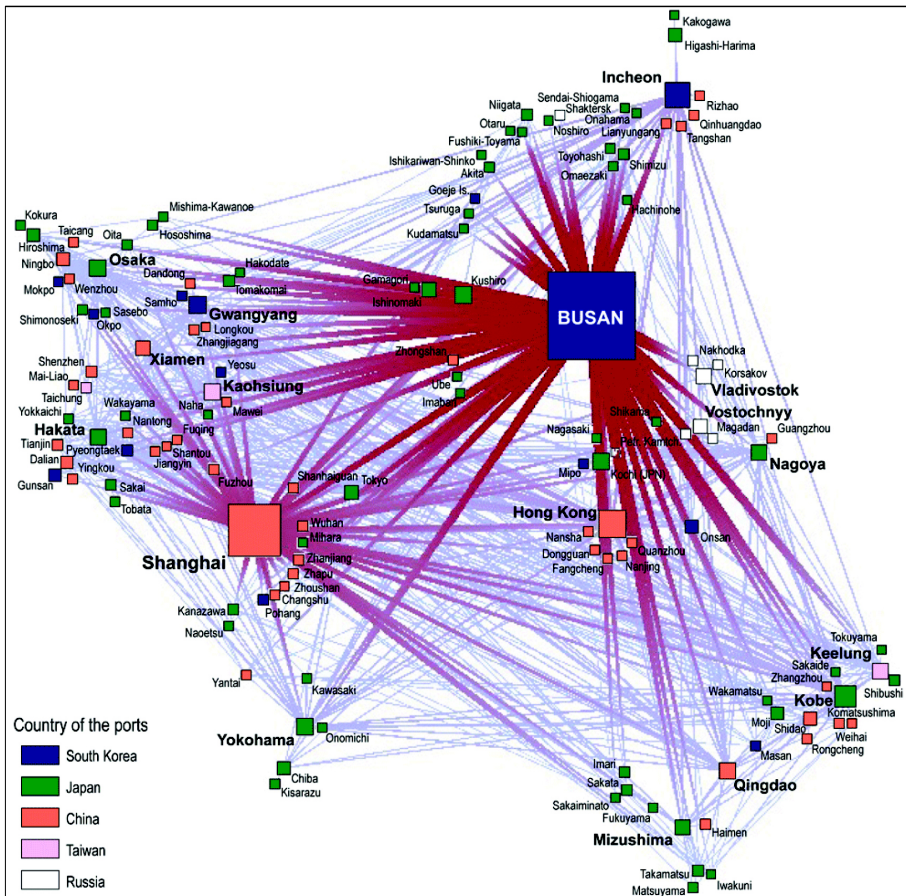

Figure 4. Liner networks within Northeast Asia, 2006

3.3 A multi-scalar approach of betweenness

In order to resituate the performance of South Korean and other Northeast Asian ports on a wider level, two methodologies are proposed and the results are examined successively.

3.3.1 Traffic distribution by main intra-regional and extra-regional connection

This methodology focuses on the degree to which some ports rely on South Korean ports or on other ports for their overall performance (Table 2). The share of rest of world is very important because it expresses a spatial reach outside Northeast Asia and therefore a higher performance, although the precise location of such long-distance connections is not indicated for better readability. This methodology can be considered as a verification of previous theoretical research on the geographical functions of container ports (Langen de *et al.*, 2002).

The first approach brings interesting results about the changes in ports' spatial reach. For South Korean ports, there has been a tendency to increase their traffic with each other, with fewer connections with other ports except for Busan that slightly increased (+5%) its direct connection outside Northeast Asia. Busan increasingly concentrates the main connections of other South Korean ports and only Gwangyang has an important connection outside Northeast Asia, despite its 39% traffic realized through Busan hub in 2006. Comparatively, Incheon has lost its long-distance connection but has maintained its important regional hub function, with 65% of its traffic connecting Northeast Asian ports.

Chinese ports have all increased their connection with South Korea except Hong Kong and Shenzhen where this link was already secondary. The three main Yellow Sea ports (i.e. Tianjin, Qingdao and Dalian) have one-third to one-half of their traffic polarized by South Korean ports in 2006 due to their location, but this trend is also increasing for Shanghai, although the share of South Korean ports represents only 17%. While this trend is accompanied by a reduction of intra-Northeast Asian connections and an increase of long-distance connections (+16% for China as a whole, +13% for Qingdao), the opposite occurs for Hong Kong and Shenzhen. Nevertheless, those two ports already had important shares of long-distance connections in 1996.

Table 2. Traffic distribution of selected Northeast Asian ports by geographical scale, 1996~2006

(Unit: % DWT)

Port, country	South Korea			Rest of NE Asia			Rest of world		
	1996	2006	96~06	1996	2006	96~06	1996	2006	96~06
Busan	7.4	14.6	+7.2	76.2	63.9	-12.3	16.4	21.6	+5.2
Gwangyang	-	39.1	-	-	47.7	-	-	13.2	-
Incheon	26.0	34.6	+8.6	68.8	65.4	-3.4	5.2	0.0	-5.2
Pohang	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0
Ulsan	38.3	66.1	+27.8	60.5	33.9	-26.6	1.2	0.0	-1.2
South Korea	5.9	13.5	+7.6	78.9	66.5	-12.4	15.2	19.9	+4.7
Hong Kong	6.9	2.7	-4.2	53.0	66.1	+13.1	40.1	31.1	-9.0
Shanghai	7.0	17.1	+10.1	89.7	71.4	-18.3	3.2	11.5	+8.3
Qingdao	11.7	28.1	+16.4	87.1	57.7	-29.4	1.3	14.2	+12.9
Tianjin	14.9	53.7	+38.8	83.7	42.1	-41.6	1.4	4.2	+2.8
Dalian	15.3	31.3	+16.0	94.7	66.8	-27.9	0.0	1.9	+1.9
Shenzhen	5.2	3.0	-2.2	71.2	75.5	+4.3	23.6	21.5	-2.1
China (excl. HK)	10.7	23.3	+12.6	80.6	52.0	-28.6	8.7	24.8	+16.1
Tokyo	0.6	3.1	+2.5	67.6	72.3	+4.7	31.9	24.7	-7.2
Yokohama	1.9	4.1	+2.2	73.0	69.5	-3.5	25.1	26.4	+1.3
Kobe	4.8	6.4	+1.6	92.0	85.4	-6.6	3.3	8.2	+4.9
Osaka	13.6	10.8	-2.8	82.3	87.8	+5.5	4.1	1.5	-2.6
Nagoya	2.4	2.5	+0.1	97.2	94.4	-2.8	0.4	3.1	+2.7
Japan	7.3	9.9	+2.6	75.2	72.0	-3.2	17.5	18.1	+0.6
Kaohsiung	9.0	10.7	+1.7	73.3	67.9	-5.4	17.8	25.5	+7.7
Taiwan	9.5	11.6	+2.1	73.9	67.5	-6.4	16.7	20.9	+4.2
Russian Far-East	34.5	52.4	+17.9	65.5	47.6	-17.9	0.0	0.0	0.0

In comparison with Chinese ports, Japanese ports have a larger share of regional reach in general (52% and 72% respectively). This share has dramatically decreased in the first (-29%) and stabilized in the latter (-3%). Connections with South Korean ports are relatively low and have only slightly increased (+3%) except for Osaka (-3%). While Tokyo and Yokohama have the most international profile with about 25% of long-distance connections, probably due to their role serving the head of the urban megalopolis and their position as Japan's easternmost gateways to the Pacific connecting the US, Tokyo and Osaka have seen their long-distance connections decreasing (-7% and -3% respectively) and their regional connections increasing (+5%).

Finally, Taiwanese ports are more international while their regional connections decrease and their share of traffic with South Korean ports has increased only slightly (+2%) compared with the increase in long-distance connections (+4%). This is the opposite for Russian ports whose traffic is dominantly regional and much concentrated with South Korean ports (52%). This confirms the role of Busan as a hub for the East Sea and for growing Chinese ports.

3.3.2 Relative positioning on multiple geographical levels from local to global

This complementary analysis is proposed because measures of betweenness within Northeast Asia may hide the fact that some ports are differently positioned by liner networks on various scales simultaneously. For instance, a given port may be very central among neighbouring ports while becoming peripheral when the study area enlarges. Table 3 proposes an index of global-local centrality that shows the possible gaps between a local and a global position for each port. The index is a ratio that relates betweenness centrality within Northeast Asia with betweenness centrality in the world. The higher the result, the better the position of the port on the world level, compared to its local position.

Unsurprisingly, Busan and Incheon have seen their index declining; this is an indication that their local position has strengthened over time, due to the primacy of their transhipment hub functions. Only Hong Kong, Shenzhen, Qingdao, Hakata and Osaka have truly improved their global position compared with their regional position, but this is because such ports are more gateways than hubs, so they tend to have a weaker position regionally, compared to their global importance as gateways connecting adjacent markets through regular line-bundling services. Also, the scattering of Japanese ports and markets along the coast have prevented from the possibility of a load centring or hub strategy towards other ports in the region (Fremont and Ducruet, 2005), while Hong Kong has progressively become a gateway for South China instead of a hub (Wang, 1998).

Gwangyang is more globalized than Busan and Incheon, probably because it has been developed more recently, backed by the two-hub port strategy aiming at connecting principally the main trunk lines. Thus, Gwangyang has fewer connections than Busan and Incheon, but it is better positioned on a wider level. The difficulty of the interpretation lies in the fact that same scores may be explained by totally different situations and factors. Shenzhen, as the three-headed port of the world's factory (i.e. Chiwan, Shekou and Yantian), has been the focus of many investments from Hong Kong firms such as Hutchinson (Airriess, 2001). The impact of Busan New Port is still limited at the time of data collection, as it is expected for completion in 2015. Overall, it is interesting to underline that the local function of South Korean ports has increased, while the global function of Chinese ports has increased. In the Northeast Asian liner system, there is complementarity rather than competition, because not any port may bid for the main hub position in the region.

Table 3. Multiscalar centrality of selected Northeast Asian ports, 1996~2006

Port	Betweenness centrality (2006)		Global-Local centrality*		
	Northeast Asia	World	1996	2006	1996~2006
Hong Kong	1,492	60,142	0.95	0.98	+0.02
Busan	6,579	54,962	0.90	0.88	-0.02
Shanghai	3,724	49,507	0.92	0.92	0.00
Yokohama	631	9,735	0.94	0.94	-0.01
Gwangyang	635	9,142	-	0.93	-
Kaohsiung	542	8,958	0.96	0.94	-0.02
Qingdao	588	8,549	0.85	0.93	+0.08
Shenzhen	105	7,498	0.92	0.99	+0.07
Incheon	1,321	7,217	0.87	0.82	-0.06
Xiamen	386	5,647	0.99	0.93	-0.06
Kobe	945	4,880	0.86	0.81	-0.05
Tokyo	363	4,166	0.95	0.91	-0.04
Keelung	380	3,525	0.96	0.89	-0.07
Hakata	597	3,188	0.74	0.81	+0.07
Ningbo	292	2,969	-	0.90	-
Ulsan	551	2,919	0.82	0.81	-0.01
Kushiro	524	2,900	-	0.82	-
Mizushima	489	2,489	0.89	0.80	-0.09
Vostochnyy	380	2,307	0.84	0.84	0.00
Vladivostok	449	2,239	0.85	0.80	-0.05
Nagoya	495	2,069	0.87	0.76	-0.11
Osaka	456	1,923	0.62	0.76	+0.14
Tianjin	165	1,680	0.94	0.90	-0.04
Shidao	264	1,453	-	0.82	-
Chiba	264	1,452	0.75	0.82	+0.06

* Calculation: 1−[(centrality Northeast Asia)/(centrality world)].

4. Conclusions

The network attributes of South Korean ports put them at the top of the port hierarchy of Northeast Asian ports. Such competitive position has been achieved in a relatively short period of time, following the country's rapid economic growth and a successful port policy based on hub strategy and modernisation.

However, a closer look at the geographical fundaments of the position of South Korean ports on various scales sheds more light on their true performance. In fact, their

role seems more regional than other major Northeast Asian ports. Also, regionally, Shanghai has superseded Hong Kong for the second rank of betweenness measures, but Hong Kong and Shenzhen comfort their global position. In addition, some main Japanese ports that are often disregarded because of high pricing, congestion and hub dependence on South Korea are in fact relatively strong in the Asian and global network (e.g. Yokohama and Tokyo). Of course, the methodology proposed in this paper tends to lower the global performance of Busan simply because it has a strong position within Northeast Asia for transhipment. Ports that rely less on hub functions tend to have a better position globally than regionally. Further analysis shall try to distinguish transhipment functions from other functions among all vessel movements in order to compare ports based on attributes of same nature.

This analysis confirms that without new strategies strengthening the current position of South Korean ports, those are likely to see their regional function even threatened by Shanghai or other Chinese rivals and their global function disappear. However, the impacts of the current global crisis are still unpredictable. One main factor to give more chances to Chinese ports to success in the long run is their role as gateways for reaching distant continental destinations within and outside China. Yet, recent evidence show that although Busan's trade traffic has diminished due to the impact of the global crisis and competition from China, its transhipment activities towards Northern Chinese ports (e.g. Tianjin, Dalian) are increasing as an effect of weather conditions affecting potential Chinese hub ports (Kang, 2009).

One possible policy direction for South Korean ports is to strengthen their connections with Chinese ports while increasing the availability and quality of port-related manufacturing and logistics activities locally through the development of integrated distriparks and industrial complexes. Further research shall improve the analytical tools of network analysis applied to maritime transport, while extending to other regions of the world for a comparative perspective.

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