Evolution Dynamics of Container Port Systems with a Geo-Economic Concentration Index: A Comparison of Japan, China and Korea

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Abstract: The advent of containerization technology has resulted in inter-port competition due to the expansion of hinterlands. Two tendencies, namely concentration and deconcentration of container traffic, have been observed during this process. This study focuses on three Eastern-Asia countries: Japan, China and Korea, to make a comparative discussion of their port concentration dynamics during 1975-2005. Based on the Herfindahl-Hirschman Index (HHI), a new index named Geo-Economic Concentration Index (GECI), which considers the competitive interactions among ports by incorporating geographical and economic characteristics of countries, is presented to measure the degree of concentration of the port systems on a country level. The results of concentration analysis using this new index show the diversified evolution dynamics of the countries concerned. Furthermore, the differences of evolution patterns are explained from the perspective of port governance structure and development policies.

Key Words: Port concentration, Herfindahl-Hirschman Index, Geo-Economic Concentration Index, Competitive interactions

1. INTRODUCTION

Regional monopoly and competition can be regarded as two distinct features of a port system. Before containerization, port markets have been perceived to be monopolistic or oligopolistic due to the exclusive geographical location of ports in a regional market. The advent of containerization technology has resulted in inter-port competition due to the expansion of hinterlands as a consequence of improved inter-modal transportation. Two tendencies, namely, concentration and deconcentration of container traffic, have been observed in the process of container port evolution (Hayuth, 1981; Notteboom, 1997; Wang et al., 2005). On the one hand, with the growing size of vessels and fewer ports of call on liner shipping service for reasons of economies of scale, container traffic has tended to concentrate on a few so-called “load centers”; on the other hand, due to congestion and diseconomies of scale at established load centers, construction of new ports with better geographical location, as well as the ambition of small ports to become the regional load centers, the deconcentration trend can also be observed during the evolution of port systems (Hayuth, 1988).

Though the concentration or deconcentration processes of container port systems may have some common features due to the nature of container shipping, port systems in different countries or regions may demonstrate various evolution patterns depending on their individual characteristics such as socio-economic background, geography, etc., which might also reflect their port development policies. The study on the dynamic changes of concentration in container port systems can provide a theoretical basis for the public
authorities to evaluate whether the observed development of their container port systems is in line with their policy objectives.

In the literature, many studies can be found on the concentration of container port systems. Some are devoted to construct models of concentration or deconcentration developments in the process of container port system evolution. One of the classical works is Hayuth’s five phase model based on the empirical study of the US container port system (Hayuth, 1981). Following his research, many empirical studies are conducted in other port systems to confirm Hayuth’s model or introduce some modification in order to reflect the specific characteristics of the port system concerned (Notteboom, 1997; Wang, 1998; Wang et al., 2005). Still, some other researches are concerned more with deep analysis of the reasons behind the observed results of concentration dynamics (Mayer, 1978; Hayuth, 1988, Baird, 1997).

Many of these studies have applied the Herfindahl-Hirschman Index (HHI) to qualitatively assess the degree of concentration in the port system (Notteboom, 1997; Wang et al., 2005). In spite of the common use of the HHI as a concentration measure, some limitations exist as regards this index. As Lijesen (2004) pointed out, the HHI is sensitive to the relevant market definition, in terms of both geographical boundaries and product homogeneity. A method applied in some previous researches to overcome this shortcoming is to select the ports carefully and classify them into different ranges that sever the same hinterland (Wang et al., 2005; Notteboom, 2006). One major issue of this method is the difficulty of deciding how ports shall be grouped into port ranges, since the results are very sensitive to different ways of grouping port ranges. Moreover, ports in the different port ranges may not be completely independent, as the ever-improving land transport connectivity and transshipment service further expand the hinterlands of ports and make some of their areas overlap. Therefore, the segmentation of port systems into port ranges may not be able to truly reflect the degree of concentration in the whole port system.

In this study, we give a particular focus on assessing the degree of concentration of port systems on a country level. We aim to develop a new index for concentration measurement which is comparable across different countries by incorporating the geographical and economic factors in the index. This paper is structured as follows: the next section describes the methodology; Section 3 shows the application results to port systems in Japan, China and Korea; Section 4 then gives a comparative discussion of the reasons underlying the observed results; and finally some concluding remarks are drawn in the last section.

2. METHODOLOGY FOR MEASURING THE DEGREE OF CONCENTRATION

2.1 The Herfindahl-Hirschman Index (HHI)

The Herfindahl-Hirschman index (HHI) is a well known concentration measure. It is defined as the sum of the squared market share of firms in a market expressed as:

$$ HHI = \sum s_i^2 $$

where $s_i$ is the market share of the $i$-th firm.

For a system with port number $n$, the value of the HHI varies from $1/n$ to 1. It increases as the shares of firms in the market become more unequal, and thus reflects the differences in share disparity of competitors in the market. In the case of the port industry, if the total container
traffic is completely dominated by one container port, the HHI reaches a maximum value of 1, which means that the port system is fully concentrated; while if the container traffic is equally divided among all container ports, the HHI equals its minimum value of $1/n$, which indicates the lowest concentration.

Since the percentage share of each firm in the market is the only determinant of the value of the HHI, the definition of the entire market becomes extremely important. As mentioned in the previous section, the result of the HHI is very sensitive to the definition of the relevant market. This is because the HHI has been derived to be an appropriate concentration measure based on a restrictive assumption regarding the nature of competitive interaction, in which all firms in a market produce a homogenous product and engage in full competition (Rhoades, 1995). In reality, however, the competitive interactions of the firms are not well known and thus make it difficult to appropriately define the relevant market. Under this rigid rule, the HHI is not appropriate to apply to the port industry since the level of competitive interactions among ports varies greatly depending on their spatial locations.

Furthermore, the HHI value is not comparable among different markets as the competitive interactions may differ from one type of market to another. For example, when we apply the HHI to port systems in different countries, the HHI value of a small country with very few ports is much likely to be higher than that of a large country with many ports. Therefore, we will introduce a new index named Geo-economic concentration index (GECI) which is applicable to the container port industry as well as comparable among countries by incorporating the geographic and economic characteristics of each country.

2.2 The Geo-economic concentration Index (GECI)

In this section, we refer back to the theoretical root of the HHI and demonstrate how the HHI can be modified into a new index that contains the special features of container port industry. As outlined by Cowling and Waterson (1976), the theoretical foundation of the HHI stressed that a positive relation exists between concentration in a market and industry profits. (Lijesen, 2004) Following the same premise, we derive a new index named Geo-economic Concentration Index denoted by GECI. The assumptions used in the derivation are as follows:

**Assumption 1**
The price (denoted by $p$) is assumed to be all the same in the entire market.

**Assumption 2**
Each port forms a local market of its own with the other ports. The quantity of the local market for the $i$-th port (denoted by $Q_i$) is expressed as

$$Q_i = \sum w_{ij} \cdot q_j (0 \leq w_{ij} \leq 1) \quad (2)$$

where $w_{ij}$ is defined as the weight of port $j$ for port $i$, which indicates the degree of competitive interaction between the two ports, and $q_j$ is the quantity of port $j$. By introducing the weight function $w_{ij}$, all the ports behave as quantity-Cournot competitor in the respective local markets. This assumption is a prerequisite to assumption 3.

**Assumption 3**
In economics, price elasticity of demand $\varepsilon$ is defined as the ratio of the change in price to the change to the quantity of the same commodity: $\varepsilon = - (\partial p / p) / (\partial Q / Q)$. It is a measure of how consumers react to a change in price (see Case and Fair, 2004). In this study, in any local market $i$, the relationship between the price $p$ and quantity $Q_i$ is assumed to obey the same price elasticity of demand $\varepsilon$, i.e.

$$\frac{\partial p}{\partial Q_i} \cdot \frac{Q_i}{p} = -\varepsilon \quad (3)$$
For the $i$-th port, its profit was defined by Cowling and Waterson (1976) as
\[ \pi_i = (p - c_i) \cdot q_i \] (4)
and the total profit of the market is
\[ \Pi = \sum \pi_i \] (5)
Maximizing the total profit of the entire market, we can get
\[ \frac{\partial \pi_i}{\partial q_i} = (p - c_i) + q_i \frac{\partial p}{\partial q_i} = 0 \] (6)
Substituting Equation 3 into Equation 6, we can obtain
\[
(p - c_i) = -q_i \frac{\partial p}{\partial q_i} = -p \cdot \frac{Q_i}{Q} \cdot \frac{\partial Q}{\partial p} \cdot \frac{\partial Q}{\partial q_i} \\
= \varepsilon \cdot p \cdot \frac{q_i}{Q_i} 
\] (7)
Now substituting Equation 2 into the above, we can get
\[ (p - c_i) = \varepsilon \cdot p \cdot \sum s_i \sum w_i s_j \] (8)
where $s_i$, $s_j$ are the shares of the $i$-th and the $j$-th port respectively. Hereinbefore, $q_i$, $q_j$ are replaced by $Q \cdot s_i$ and $Q \cdot s_j$ respectively, where $Q$ is the quantity of the entire market.
Substituting Equation 8 into Equations 4 and 5, we can get the profit of the entire market:
\[ \Pi = \sum \pi_i = \varepsilon \cdot pQ \cdot \sum \frac{s_i^2}{w_i s_j} \] (9)
Similar to the HHI, the new index GECI can be defined as
\[ GECI = \sum \sum \frac{s_i^2}{w_i s_j} \] (10)
Now, let us consider a case for all ports located within a single place. In this case, $w_{ij}=1$ for any $i$ and $j$, therefore Equation 10 becomes
\[ GECI = \sum \frac{s_i^2}{s_j} = \sum s_i^2 \] (11)
We can see that the GECI becomes the HHI in this case.
Let us try another case for ports isolated from each other. In this case,
\[ w_{ij} = \begin{cases} 1 & \text{for } i = j \\ 0 & \text{for } i \neq j \end{cases} \] (12)
Then Equation 10 becomes
\[ GECI = \sum \frac{s_i^2}{s_j} = \sum s_i = 1 \] (13)
It means that the markets are monopolized by all the ports in their own domains.
Equation 10 gives a general form to assess the degree of concentration in a dispersed market; however, the weight function $w_{ij}$ has not been specified yet. In the following paragraphs, we recommend a sample weight function for the GECI considering the feature of container port system.

In the researches on port competition, competition among ports is often associated with the level of sharing of the common potential hinterland. By interpreting the degree of competitive
interactions between ports as the degree of overlapping hinterland, we assume that the degree of competitive interaction is affected by the distance between the two ports; obviously it obeys a decaying function of the distance. Using the OD data of *International Container Cargo Flow Survey 2003* in Japan, we can plot the probability distribution of the cargo-transportation distance as shown in Figure 1. The result shows that the probability of choosing a port is well fitted to an exponential function of the distance from the cargo origin/destination to the port. Similarly, the degree of overlapping hinterland \((w_{ij})\) of ports \(i\) and \(j\) with distance \(r_{ij}\), can be expressed as an exponential function of the distance:

\[
\frac{\text{opt}}{\text{exp}} \left( -k \cdot \frac{r_{ij}}{D_{\text{opt}}} \right) = \exp\left( -k' \cdot r_{ij} \right)
\]

where \(k' = k / D_{\text{norm}}\); \(k\) is a constant and \(D_{\text{norm}}\) is a distance normalization factor, which is defined as the economically reasonable interval of ports in each country.

![Figure 1 Probability distribution of cargo-transportation distance](image)

Since countries differ in geographical scale, land transport performance etc., the degree of competitive interaction among ports with respect to the distance may also vary from country to country. We assume that each country has an economically reasonable interval of ports based on its own characteristics. By introducing the economically reasonable interval of ports \((D_{\text{norm}})\), the degree of competitive interactions with respect to distance can be normalized.

In order to obtain the economically reasonable interval of ports \((D_{\text{norm}})\), we attempt to get the optimal number of port \((n_{\text{opt}})\) by minimizing the unit transportation cost of container cargo including land transportation cost and terminal operation cost. We simplify the country’s geographic shape and cargo transportation as Figure 2:

![Figure 2 A simplified model of cargo transportation](image)
distance \( (L_t) \) is simplified as
\[
L_t = \frac{L_D}{2} + \frac{L_C}{2n}
\]  
where \( L_D, L_C \) and \( n \) are the average depth of the country from the coastline, the length of the coastline and the number of the container ports, respectively. If the land transportation cost is proportional to the transportation distance \( L_t \), the unit transportation cost \( (C_t) \) can be
\[
C_t = a \left( \frac{L_D}{2} + \frac{L_C}{2n} \right)
\]  
where \( a \) is a unit transportation coefficient. Moreover, the average unit terminal operation cost \( (C_c) \) is assumed to be an inverse proportional function of average trade volume:
\[
C_c = b \cdot \left( \frac{T}{n} \right)^{-\alpha}
\]  
where \( \alpha \) is the economies of scale in port operation and \( b \) is a constant. Then, the unit cost of a cargo \( (C_u) \) would be
\[
C_u = C_t + C_c = a \left( \frac{L_D}{2} + \frac{L_C}{2n} \right) + b \cdot \left( \frac{T}{n} \right)^{-\alpha}
\]  
Minimize \( C_u \) by
\[
\frac{\partial C_u}{\partial n} = 0
\]  
we can get an optimal number of ports \( (n_{\text{opt}}) \) to be
\[
\frac{n_{\text{opt}}}{L_C} \propto \left( \frac{T}{L_C} \right)^{\beta}
\]  
where the coefficient \( \beta \) is \( \alpha / (1 + \alpha) \). Our regression analyses using the data of the actual number of ports, the length of coastal line, and international trade volume in 8 countries, namely: Japan, China, Korea, USA, UK, France, Spain and Italy, in the years 1977, 1984, 1994 and 2004, give a value of \( \beta \) equivalent to 0.5 as shown in Figure 3.

![Figure 3 Regression analysis of parameter \( \beta \)](image)

Thus, by setting \( \beta \) to 0.5, we can define relation between the optimal number \( (n_{\text{opt}}) \) of a port system with the length of the coastline \( (L_C) \) and the total international trade volume \( (T) \) as expressed in Equation 21:
\[
\frac{n_{\text{opt}}}{L_C} \propto \left( \frac{T}{L_C} \right)^{1/2}
\]  
Based on Equation 21, \( D_{\text{norm}} \) can be also described as a function of \( T \) and \( L_C \):
\[
D_{\text{norm}} = \frac{L_C}{n_{\text{opt}}} \propto \left( \frac{L_C}{T} \right)^{1/2}
\]
Therefore, the relationship of $k'$ between any two countries (denoted by $k'_{0}$ and $k'_{1}$) can be derived as:

$$
\frac{k'_{1}}{k'_{0}} = \left( \frac{T_{1} L_{0}}{T_{0} L_{1}} \right)^{1/2}
$$

(23)

By employing Equation 23, we can obtain the value of $k'$ for each country if the value of a reference country is available. Hereinbefore, $T_{0}$ and $L_{0}$ are the length of the coastline, and the international trade volume, respectively of a reference country (Japan is used as a reference country in this study); and $T_{1}$ and $L_{1}$ are the length of the coastline, and the international trade volume, respectively of the country concerned.

3. APPLICATION TO PORT SYSTEMS IN JAPAN, CHINA AND KOREA

In this section, we apply to developed index to port systems in, Japan, China and Korea, and examine their concentration dynamics during the period 1975-2005 (for China, 1980-2005). In addition to identifying the evolution tendencies toward concentration or deconcentration by time series, we will also make a horizontal comparison of the degree of concentration among the three countries. The study on the concentration dynamics of these three neighboring countries may provide us some insights on their present situation and development strategies.

3.1 General overview of container port development in Japan, China and Korea

Figure 4 Total container throughput in Japan, China* and Korea

(*Container ports in HongKong and Taiwan are excluded)

Figure 4 gives a general overview of the total container throughput and the number of container ports by size in Japan, China and Korea during the last three decades. (In this study, container ports all refer to coastal container ports.) Since China’s containerization happened later than Japan and Korea, the study period of China covers only from 1980 to 2005, while
Japan and Korea covers from 1975 to 2005. The total container throughput in Japan has displayed a very stable growth over the last 30 years, evolving from 1.8 million TEU in 1975 to 16.7 million in 2005. Throughput of Korea started with only 189 thousand TEU in 1975, gradually caught up with Japan, and reached almost the same level as Japan with 15.2 million TEU in 2005. The most striking growth in total throughput is demonstrated by China, with an exponential increase of 75 million TEU in 2005, more than four times that of Japan or Korea.

In terms of the number of ports, the increases in China and Japan are quite remarkable, growing from 8 and 0 in 1975 to 64 and 83 in 2005 respectively. For Korea, only two container ports existed in the whole country before 1990. Even though the number of ports increased to 12 in 2005, Korea has still much fewer ports than Japan considering that both countries have almost the same total throughput in 2005. Taking a look to the port size, we may notice that China and Korea have respectively 3 and 1 super large container ports with each having a throughput of more than 5 million TEU in 2005, while no such port exists in Japan. Instead, Japan has more medium-sized ports handling 1 million to 5 million TEU. A simple comparison of the number of ports and port sizes gives a general indication that Japan’s port system is relatively deconcentrated, while that of China and Korea are quite concentrated. A more profound quantitative analysis in the following part may reveal more information on the port concentration dynamics of these countries.

3.2 The data and parameter

As indicated by Table 1, the data we used for assessing the degree of concentration cover a large percentage of the total throughput in each country to better reflect their port system concentration. For example, the data of 2005 include 34 containers ports in Japan with total throughput coverage of 98%, 26 containers ports in China with total throughput coverage of...
91% and 8 containers ports in Korea with throughput coverage of more than 99%. The locations and sizes of the ports considered are shown in Figure 5. In the case of the eliminated ports, their respective market shares of less than 1% will not significantly affect the results.

<table>
<thead>
<tr>
<th>Table 1 Data Coverage of the study</th>
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<tr>
<td>Number of the ports concerned</td>
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<tr>
<td>Throughput of the ports concerned (a)</td>
</tr>
<tr>
<td>Total throughput (b)</td>
</tr>
<tr>
<td>Coverage of the throughput (a/b)</td>
</tr>
</tbody>
</table>

Parameter \( k' \) for the three countries in each year should be determined to get the concentration results. As shown in Figure 1 in the previous part, by using the OD data from container cargo distribution survey 2003 in Japan, we can obtain the value of parameter \( k' \) to be 0.0088 km\(^{-1}\) and use it as the reference value. As listed in Table 2, all the values of \( k' \) in different countries and years can be calculated with Equation 23.

<table>
<thead>
<tr>
<th>Table 2 Values of ( k' ) in Japan, China and Korea in each year</th>
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<tbody>
<tr>
<td>Country</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>China</td>
</tr>
<tr>
<td>Japan</td>
</tr>
<tr>
<td>Korea</td>
</tr>
</tbody>
</table>

| China   | 0.0023 | 0.0032 | 0.0041 | 0.0063 | 0.0082 | 0.0143 |
| Japan   | 0.0028 | 0.0043 | 0.0046 | 0.0060 | 0.0074 | 0.0077 | 0.0088 |
| Korea   | 0.0033 | 0.0058 | 0.0073 | 0.0108 | 0.0149 | 0.0169 | 0.0217 |

3.3 Evolutions of the HHI and the GECI

Figure 6 reveals the concentration dynamics of port systems in Japan, China and Korea by applying the HHI and the GECI. Using the conventional HHI, the concentration of the port system in Korea is said to be high while those of both China and Japan are comparatively low. Due to its small geographical area, one dominant port in Korea may be enough to satisfy the transport demand leading to a high concentration rate. On the other hand, Japan tends to construct more ports since it has a long coastline and an elongated geographic shape. Likewise, China’s large geographical area also requires more ports resulting in a smaller market share for each port, and consequently demonstrating a much deconcentrated port system as shown in the figure. Without considering these differences, the concentration levels of the three countries are not comparable because the results are highly influenced by the country’s geographical characteristics and the transport demand.
When we consider the degree of competitive interaction and incorporate the length of coastline and international trade volume in the new index, the influence of such differences can be partly mitigated. From Figure 6, we can observe that the GECI results to elevated concentration levels of Japan and China. Moreover, the dynamic changes of concentration in each country using the new index also show some variations from the results of the conventional HHI.

**Japan**
Japan is observed to be consistently evolving to a more deconcentrated system based on the conventional HHI, while the GECI suggests that its port system has a fairly steady level of concentration with minor fluctuations. In fact, the total share of the top five ports, namely Tokyo, Yokohama, Nagoya, Kobe and Osaka in Japan has decreased from 97% to 77%, which apparently supports a deconcentration trend. However, as shown in Table 1 previously, the number of ports in Japan has increased from 7 to 64 indicating that the shares of the individual local ports still remain very limited. Given that increasing international trade volume requires more constructions of new facilities, the results shown by the GECI appear to be more reasonable.

**Korea**
An obvious concentration trend from 1975 to 1990 can be observed both from the HHI and the GECI in the port system of Korea. The striking development of Busan during this period is an important reason for such concentration trend. Busan’s market share has increased from 91% in 1975 to 95% in 1990. Its dominant position results in a very large value of both the HHI and the GECI representing a highly concentrated port system. Due to the serious congestion problem in Busan, a new container port Gwangyang, was developed and put into operation in early 1990s. The development of this new large port has ended the extreme domination of Busan and led to a deconcentration trend after 1990. However, the deconcentration trend indicated by the GECI is quite moderate compared to the HHI. This might show that the deconcentration trend in this period is mainly the consequence of
increasing transport demand that requires more facilities. Therefore, by mitigating the influence of the growth in international trade volume, the GECI obtains a moderate decline in the degree of concentration.

China
The most significant difference between the degree of concentration indicated by the HHI and the GECI can be found in the case of China’s port system. We will take a closer look at China’s case in order to understand more the nature of the GECI.

Though there are five port ranges promulgated in China, which are Bohai Bay port range, Yangtze River Delta port range, Southeast coastal area port range, Pearl River Delta port range, and Southeast coastal area port range, due to the limited number of ports in Southeast and southwest coastal area port range and relatively close location with Pearl River Delta port ranges, we grouped the port system in China into three port ranges: Northern Port Range (NPR) consisted of the ports in Bohai bay area, Middle Port Range (MPR) consisted of ports in Yangtze River Delta area, Southern Port Range (SPR) consisted of ports in Southeast coastal area, Pearl River Delta area and Southwest coastal area. Both the GECI and the HHI of the three port ranges and entire China are plotted in Figure 7. We can observe that the values of the GECI for entire China in each period is more or less close to the average values of the port ranges; however, the value of the HHI for entire China is much smaller than that of each individual port range. When assessing the degree of concentration in entire China using the HHI, all the ports are regarded to be in a single market and engaged in the same level of competition. But in fact, the level of competition of ports in different port ranges is way less than that of ports in the same port range. Therefore, the degree of concentration is greatly underestimated. This comparison reveals that the GECI is more consistent when applied to different market scales. So if we compare the concentration level in different country scales, the GECI appears to be more appropriate than the HHI.

Figure 7 Evolutions of the HHI and the GECI of port ranges in China
Another remarkable observation indicated by the GECI is that all the port ranges and entire
China illustrate a similar evolution process. From 1980 to 1990, a deconcentration tendency can be observed both on the port range level and country level. In the history of China’s container port development, this is a period when China started to accelerate the construction of container terminals in response to the trend of containerization. Many new container ports were constructed during this period but all Chinese ports acted only as feeder ports to some other Asian ports and were relatively small in size. The declining trend ended in the 1990’s and a strong growth pattern toward concentration was evident from 1995 to 2005. Accordingly, the share of the eight main ports in China (Shanghai, Shenzhen, Qingdao, Ningbo, Tianjin, Guangzhou, Xiamen, and Dalian) has increased from 67.4% in 1995 to 80.3% in 2005. The growth in cargo handling volume of these main ports has contributed to the observed concentration trend during this period.

Comparison of the three countries

By using the GECI, we can compare the degree of concentration in the three countries. Though the degree of concentration varies from year to year, the concentration level of Japan’s port system is much lower compared to those of China and Korea in any year. The concentration level of China’s port system has remained in between Japan and Korea while Korea has continuously posted a high degree of concentration even after the slight decline in recent years. We summarize the results of the concentration analysis in figure 8:

![Figure 8 Comparison of the concentration dynamics in Japan, China and Korea](image)

Even after considering the influences of economic and geographical factors, the port systems in the three countries still demonstrate varied evolution patterns in terms of concentration dynamics. In the next section, we discuss the institutional aspects, such as port governance issues and port development policies, in order to find out some possible explanations for the different concentration dynamics described above.

4. DISCUSSION

Reasons accounting for the common features of concentration or deconcentration tendencies, such as technology advancement and economies/diseconomies of scale in port operation, were explicitly elaborated by many researchers (Mayer, 1978; Slack, 1994). Little emphasis, however, was given on the factors that cause the different concentration dynamics of the port systems on a country level. As we described above, geographical and economic influences could not sufficiently interpret the different evolution patterns of port concentration in Japan, China and Korea. In the following section, therefore, we will give special focus on port governance structure and port development policies of the countries concerned to see whether
the differences in these institutional aspects could provide reasonable explanations for the observed results of the foregoing concentration analysis.

4.1 Japan: Decentralized port governance, deconcentrated port development
In Japan, according to the *Port and Harbor Law* enacted in 1950, all aspects of development, management and operation of individual ports are entrusted to local governments. Local port authorities are responsible for making a master plan of port development and submitting it to the Ministry of Land, Infrastructure, Transport and Tourism for approval to be later incorporated into the Five-Year port consolidation plan. The *Port and Harbor Law* also regulates the share of central government subsidy on the local port construction depending on the category of the port. However, the allocation of the budget is completely controlled by the central government. Indeed, the central government subsidy program is used to balance out the cost differences between ports in the same category so that each port under the same category could have equal opportunity for development (Terada, 2002). Under this framework, it is not possible for the central government to choose specific container terminals with competitive advantages for intensive investment. This may account for the fact that several medium-sized ports exist in Japan but no super large ports exist.

Moreover, local governments, having the authoritative power in making port development plans, are strongly motivated by the central government subsidy program to increase their financial demands for port construction. According to the research of Terada (2002) on the financial system of local governments, the public investment in port construction is believed to be an effective way of income transfer under the tax revenue sharing system. Meanwhile, the expected industrial development through infrastructure improvement as well as the economic effects brought by the public expenditures also stimulates the local governments to incorporate a port development plan in the Five-Year port consolidation plan.

In terms of port development policies, the construction of new ports in local areas to facilitate industrial development was prioritized in response to the industrial decentralization since 1962. In the long term port development plan *Ports and Harbors in the 21st century* enacted in 1985, and the 7th and 8th five-year consolidation plans (1981-1985, 1985-1990), special focus was given to the container terminals construction in the newly developed industrial areas due to growing demand for short-sea shipping brought by the economic cooperation with Asian countries as well as the expensive land transport and domestic feeder service costs in using the major container ports.

The decentralized port governance structure together with the objective for port development are considered to be among the main reasons that can account for the deconcentration of Japan’s port system.

4.2 China: Decentralized port governance, concentrated port development
China has experienced a series of institutional reforms in terms of port governance structure during the past 30 years. Before 1984, central government exerted total control over all port activities and decision-making under the planned economic system. With the experimental structure reform carried out in Tianjin port in 1984, China started to gradually change to so-called “dual administration” that ports are jointly governed by the central government and local government. In 2003, the *Port Law of the People’s Republic of China* was enacted which stipulated that the central government is in charge of strategic planning of the port network while ports are mainly owned and managed by different levels of local government. This marked the changing of China’s port governance structure to a fully decentralized system.
In addition to devolving the authority to local governments, the reform also diversified the financial sources for port development, the most distinct feature of which is the utilization of foreign investment. In 1985, the State Council of China has promulgated a policy named *Preferential treatment to Sino-Foreign Joint Ventures on Harbor and Wharf Construction*, in which Joint Ventures are encouraged to be established with preferential treatments (Wang et al., 2004). During the decentralization process, local governments gain certain autonomy in sourcing the port development funds. However, not all the ports have equal opportunities in attracting foreign investments. The profit-oriented global terminal operators choose the ports with relative advantages in terms of geographical location, potential economic growth of their hinterlands, etc. With the foreign capital, advanced technology and management know-how provided by the foreign investor, these favored ports can provide better performance resulting in expanded hinterland and foreland. In fact, all of the 8 main ports in China, namely, Shanghai, Shenzhen, Qingdao, Ningbo, Guangzhou, Tianjin, Xiamen, Dalian, have foreign participation in their terminal construction and operation (Wang et al., 2004). The foreign participation has accelerated the growth of the ports with competitive advantage, and may contribute to the strong concentration trend observed after 1995 in China’s port system.

Besides port governance issues, two polices issued in mid-1990s provide more evidences to support the institutional influences on the strong concentration trend observed from 1995 to 2005. One is the State Council's approval in 1995 of the setting up of Shanghai International Shipping Centre with the large deep-water terminals construction in Yangshan Island. Another is the policy issued by the Ministry of Transport (MOT) in 1997 which called for “developing ocean shipping routes, limiting short-sea feeder service and encouraging inland feeder service” by limiting the market access of short-sea route and increasing the port charges for vessels engaged in short-sea shipping service by 20% (China Shipping development annual report, 1998). From the above two policies, we can clearly see the central government’s intention to concentrate development of the large ports to increase the direct ocean shipping routes which possibly led to the concentration trend observed.

**4.3 Korea: Centralized port governance, concentrated port development**

Though the authority responsible for port development has changed from Korea Maritime and Port Administration (KMPA) in 1976 to Ministry of Maritime Affairs and Fisheries (MMAF) in 1996, port development in Korea has always been under the full control of central government (Cullinane and Song, 1998). Not until 2003, with the establishment of the Busan Port Authority, and followed by the Incheon Port Authority in 2005, that Korea has moved forward to give the local government certain autonomy in port development. Under the centralized port governance system, intensive investment tends to be made to ports with competitive advantage in order to achieve the strategic development at the national level. The dominant position of Busan over a long period provides the best evidence. In fact, to develop Busan and Incheon into international standard container ports was the primary objective of Korea’s port development strategy since 1970’s (Cho, 2003). However, due to the geographical disadvantage of the Incheon port which is far from the truck line, Busan has enjoyed the dominant position until the new construction was made in Gwangyang to release the congestion problem of Busan. In the Master plan for container port development established in 1999 by MMAF, Busan and Gwangyang were designed to be the main hub ports and prioritized for development (Lee, 1999). The positioning of these two ports were further upgraded to “Northeast Asia Logistics Hub” in the country’s strategy of port development promulgated in 2002. These development plans show that Korea is quite keen on
the concentrated development of the hub ports, which appears in harmony with our analysis results of a highly concentrated port system in Korea.

The above discussion on port governance structures and development policies provides quite good interpretation for the observed concentration dynamics. It not only supports the credibility of the GECI on reflecting the degree of concentration of port systems, but also indicates the high influences of these institutional factors on the concentration dynamics of port systems.

5. CONCLUSIONS

This paper proposed a new index name Geo-economic concentration index (GECI) to measure the degree of concentration of container port system in different countries. The new index assesses the degree of concentration considering additional factors other than market share which is commonly adopted in the conventional methodologies. Two improvements have been made in the GECI, namely: (1) introduction of the degree of competitive interaction among ports which makes the index be applicable in the container port system; and (2) inclusion of the geographic and economic characteristics of countries which makes the index comparable among port systems in different countries. The developed index was applied to container port systems in Japan, China and Korea to examine their concentration dynamics.

Evaluating the degree of port concentration by applying the developed index can help the public authorities to scientifically understand the actual situation of the port concentration by comparing with the other countries, and provide a theoretical basis for the policy making on the concentrated development or balanced development of port facilities over the country.

However, the index proposed in this study is still not very refined. In order to improve the applicability of the index and considering the data availability, we made some assumptions to simplify the index. For example, the degree of competitive interaction between ports is only estimated by the distance among ports. Some factors, such as the commodity type and the shipping network of the port may also have influence on the competition among ports. The weight function of the degree of competitive interaction can be further improved in the future study. Moreover, land transport performance is not yet included in determining the competitive interactions among ports.

Notes: All data concerning container throughput are drawn from the International Containerization Yearbooks, China Ports Yearbooks, Statistics of Japanese Port and Korea shipping statistics with data from the International Containerization Yearbooks prevailing whenever conflicts or inconsistencies in the data arise.

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