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The evolution of container port group in Bohai Rim of China

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중국 보하이만 컨테이너 항만의 진화에 관한 연구

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Abstract Since China's economic reform in 1978, international trade has enormously flourished and the port industry is reckoned as a key factor contributing to this growth. This study examines the Bohai Rim port group in the scope of top three largest ports Qingdao, Dalian and Tianjin. By utilizing indicators including concentration ratio (CR), Herfindahl-Hirschman index (HHI), the Gini coefficient and the Lorenz curve as well as shift-share analysis (SSA), the concentration level of this port group in the period 2004-2016 is discussed. As a results, CR demonstrates a decrease during the studied period with a minor fluctuation, and HHI index shows a trend of deconcentration with Bohai Rim port group. In addition, SSA indicates that during the period 2004-2016, the overall shift index of Qingdao port was -1.371 meanwhile with Tianjin and Dalian port were 0.118 and 1.252 in turn. These results suggest that the growth in regional influence of Tianjin and Dalian ports would motivate to the deconcentration pattern in Bohai Rim region. The findings assist decision makers and scholars to obtain knowledge about the port development this region. Considering the geographic position of these three ports as the gate of northeast China, it is suggested that these three ports could explore their advantages and cooperate with the small ports in the surrounding area to enhance their influences in the future study.

Key Words : Bohai Economic Rim, Concentration Level, Herfindahl-Hirschman Index, Gini Coefficient, Lorenz Curve, Shift-Share Analysis

요 약 1978년 중국의 경제개혁 이후, 국제무역은 빠른 속도로 증가되었고, 항만산업은 성장을 가능하게 하는 중요한 요소로 인식되고 있다. 본 연구는 보하이만의 최대 항만인 청도, 대련, 천진항 대상으로 분석을 시행한다. CR 분석, 허핀달-허쉬만 분석, 지니계수, 로렌츠 커브 및 전이분석을 이용하여, 2004-2016년도 항만의 집중도를 분석한다. 연구결과, CR 지수는 작은 변동을 보이면서 감소하며, 허핀달-허쉬만 지수는 분산화 경향을 나타냈다. 2004-2016 기간 동안 전이분석 결과, 청도항은 -1.371인 반면, 천진과 대련항은 각각 0.118, 1.252을 나타냈다. 또한 천진항 및 대련항의 성장이 보하이만 분산화 경향을 주도하였다. 연구결과는 해당지역의 항만개발에 관여하는 의사결정자 및 학계에 필요한 시사점을 제공한다. 향후연구에서는 중국 동북지역 관문에 위치한 최대항만이라는 지리적 이점을 고려하여 근처 중소형 항만과의 협력방안을 탐색할 필요가 있다.

주제어 : 보하이만, 집중도, 허핀달-허쉬만 지수, 지니계수, 로렌츠 커브, 전이분석

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1. Introduction

Structurally, port is functional as a load center or followed a trend of peripherality when considering the level of concentration. Since the containerization era, this significant theory was established by Hayuth (1981) [1] for the first time, regarding to the development stage of container port system.

In China, the expansion of port industry was acknowledged with the economic reform in 1978, a milestone that leads to the transformation of manufacturing and international trade. So far, the country has owned a huge maritime transportation network. In 2006, the Ministry of Transportation released the national plan for the spatial allocation of coastal ports to optimize port layout, increase the comprehensiveness of services provided by port groups, and strengthen the dominant role of large ports. Based on national economic background, features of regions, the relations between ports and the economic rationality of main cargo traffic, this plan divided the coastal ports into 5 port groups, named Bohai Rim, Yangtze River Delta, Southeast Coastal, Pearl River Delta and Southwest Coastal port group.

Among those, the Bohai Rim port group is represented by three main ports; Qingdao, Dalian, and Tianjin; which jointly contribute to the socio-economic development of coastal and inland region in Northern China. This port group is engaged as the gateway for the regional economic development and facilitates the hinterland accessibility with a large land, river and ocean network [2]. Externally, Bohai Rim port group geographically faces Northeast Asia and the rapidly emerging Asia-Pacific economic circle meanwhile internally, it is supported by China's capital city Beijing and the municipality Tianjin even tightly connected with the Northeast, North, and Northwest region therefore this port group is equipped with irreplaceable logistics advantages [3-5]. Benefiting from the growth of international trade, these three ports have attained rapid expansion and cultivated their respective advantages, nevertheless, their growth is envisaged a couple of issues. Taking advantage of geographical location, Qingdao, Dalian, and Tianjin ports are among the largest ports in Bohai Rim however, these three ports have been facing a situation of tripartite confrontation during their evolution. This phenomenon compels these ports to simultaneously cooperate and fiercely compete to one another [6].

Nevertheless, they are among prominent ports in Bohai Bay Rim regarding the cargo throughputs. Being an important factor to evaluate the development of a port, the cargo throughputs is useful to reflect the logistics capacity, operation capacity and attraction of a port [7]. This is a prevailing topic to identify the growth of a port system but there is currently limited concern about it with Bohai Bay Rim ports. In this respect, the aim of this study is to analyze the evolution of Bohai Rim port group using container cargo volumes, focusing on top three ports Qingdao, Tianjin and Dalian in the period 2004-2016. The analysis would be supported by the following functional instruments: concentration ratio (CR), Herfindahl -Hirschman Index (HHI), the Gini coefficient and the Lorenz Curve as well as shift-share analysis (SSA).

2. Literature review

The level of concentration has been defined with the port system since the early phase. In 1963, Taaffe et al. introduced the five-phase model [8], in which the degree of port concentration developed together with certain hinterland routes and urban centers. Resultingly, small ports would be replaced by port systems with high level of integration and consolidation. The same trend was pointed out by Rimmer (1961) when the occurrence of concentration with port systems since 19th century was defined, causing by the predominance of large ports with smaller ones [9]. Kenyon (1970) encouraged this tendency with driving forces such as the increasing

quantity of activities and infrastructure enhancements in large load centers [10]. Until 1986, Barke released a model which is identity with Taaffe et al.'s but the trend of deconcentration is discussed as the primary issue [11]. This model argued that the overwhelming transport leads to the under controllable congestion then port operation is encouraged to move far away from urban area to achieve the efficiency.

Since the era of containerization, the level of concentration has been widely discussed in different perspectives. Hayuth (1981) released the five-phase model that specifically illustrated the movement of cargo and correlated driving forces. Discussing about the port operation in North Korea, Ducruet et al. (2009) described the deconcentration was resulted from a variety of factors, especially governmental policy when North Korea allowed the establishment of Chinese terminals in this country [12]. It led to the downfall of Nampo, the largest North Korean seaport in many years. In 1997 and 2010, Notteboom pointed out the tendency of deconcentration in European port system, contributing by factors such as technological and organizational enhancement as well as governmental policies [13,14]. Furtherly, Wilmsmeier and Monios (2013) identified the deconcentration with container traffic in UK port system by the growth of transshipment in continental ports [15].

Owning huge seaports in Asia, there are several studies about the concentration level of Chinese ports. Wang (1998) discussed about the development path of Hong Kong container port - the busiest container hub in 1990s [16]. Other studies regarding to the degree of concentration in Chinese ports were released by Slack and Wang (2002) or Le and Ieda (2009) [17,18].

In recent research, various studies were suggested regarding the evolution of ports such as concentration and deconcentration [19-21]. In this paper, analyses would be conducted with Northern container port range lying in Bohai bay area. Previous studies pointed out distinctive port operational perspectives from co-operation, integration to competition, listed as Chen and Cheng (2009), and He (2010) [22,23] but the lack of a typical assessment on concentration level is recognized. Meanwhile, the investigation of Le and Ieda (2009) did not provide a thorough understanding about the Bohai bay, one of the busiest port ranges in China.

3. Methodology

The methodologies, which identify the concentration level, are defined in this section including concentration ratio (CR), the Herfindahl-Hirschman Index (HHI), the Gini coefficient & the Gini coefficient meanwhile the shift-share analysis (SSA) would examine the cargo volume shifting among ports in the system.

3.1 Concentration ratio (CR)

The concentration ratio is a functional instrument to identify the market share of certain largest firms, indicated by the index 'k' (k= 1, 3, 5, 7…), in a market. The power of defined firms would be characterized by the level of concentration ratio:

$$CR(k) = \Sigma^{k_{i=1}} S_i \quad (1)$$

expresses the proportion of market share in ith largest firm (i=1, 2,…, k). k =1 means the assessment with solely the 1st firm and k=3 determines the top 3 heading firms.

3.2 The Herfindahl-Hirschman Index (HHI)

This is a prevailing measure to approach into the level of concentration in a certain market as seen in Notteboom (1997) or Le and Ieda (2009). It is understood as the sum of squared market share of firms and described by the following formula:

$$H = \frac{\sum_{i=1}^{n} TEU_i^2}{(\sum_{i=1}^{n} TEU_i)^2} and \frac{1}{n} < H < 1 \quad (2)$$

Notwithstanding that Le and Ieda (2009) applied this methodology into the ports in entire China and

concluded that the level of competition of ports in different port ranges is underestimated. Nonetheless, this study would concentrate on only the Bohai-rim container ports so the objectives are explicitly in the same level of competition.

3.3 The Gini coefficient and the Lorenz curve

The Gini coefficient is assigned to measure the inequality of a distribution, ranged from 0 to 1. In terms of income equality, the perfect equality is represented by 0 meanwhile the highest level of inequality is corresponded with 1. The Gini coefficient is covered by the uniform distribution line and the Lorenz curve of the distribution as below:

$$G = \frac{n+1}{n} - \frac{2\sum_1^n (n+1-i)x_i}{n\sum_1^n x_i} \quad (3)$$

Specifically:

n: the number of container terminals

xi: the cumulative market share regarding the throughput of container terminals from the lowest to highest.

The Lorenz curve is represented as a curved line which depicts the cumulative percentage of variables, specifically a certain number of firms in an industry with the range of n from 1 to n [24].

3.4 Shift-share analysis (SSA)

Shift-share analysis is utilized by De Lombaerde and Verbeke (1989) [25] in examining port traffic flows in Europe and average growth of the traffic in a market [26,27]. This study would concentrate in the shift effect which only covers the container cargo volume (TEU) shift among the terminals in a port range. The calculation of shift-share analysis is as followed:

$$SHARE = \left(\frac{\sum_{i=1}^n TEU_1}{\sum_{i=1}^n TEU_0} - 1\right).TEU_0 \quad (4)$$

$$SHIFT_i = TEU_{it_1} - \frac{\sum_{i=1}^n TEU_{it_1}}{\sum_{i=1}^n TEU_{it_0}}.TEU_0 \quad (5)$$

$$ABSGR_I = TEU_1 - TEU_0 = SHARE_i + SHIFT_i \quad (6)$$

In detail: SHAREi: the share effect in TEU of port i for the period t1-t0.

SHIFTi: the shift effect in TEU of port i for the period t1-t0.

ABSGRi: the absolute growth in TEU of port i for the period t1-t0.

TONi is the cargo volume of port i.

n: the quantity of ports.

4. Case study

The Bohai Rim region is a large economic zone covering the entire coastal region of the Bohai Sea and a partial zone of the Yellow Sea. As seen, Fig. 1 illustrates the geographical location of three observed ports in Bohai Rim.

Fig. 1. Allocation of seaports in Bohai Sea Rim

The container cargo volume of these three ports is described in Fig. 2. In general, the throughputs of these three ports is witnessed a continuous increase from 2004 to 2016. In terms of growth rate, Dalian port was heading the market with 3.4% growth rate meanwhile Tianjin experienced a 2.8% growth rate and the leading cargo volume port, Qingdao, only attained 2.5% growth rate in this period.

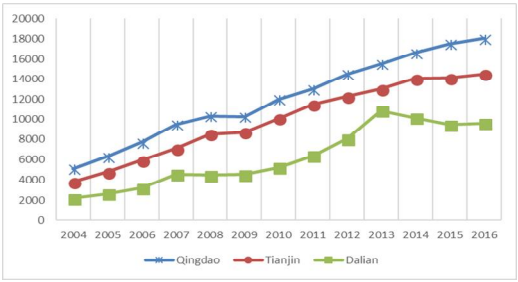

Fig. 2. Cargo volume of three examined ports in the Bohai Rim (2004-2016)

Fig. 3 illustrates the CR of the Bohai Rim port group (2004-2016) with solely the leading port in discussion. The result demonstrates a decrease of the CR during the studied period with a minor fluctuation. A downward trend, which started from 2007 to 2013 with a decrease to underneath 40% of the market share, indicates a lesser extent of oligopoly in the whole market. However, since 2013 to 2016, the constant CR increase to 0.43 might be a signal of the tendency of concentration in the later time.

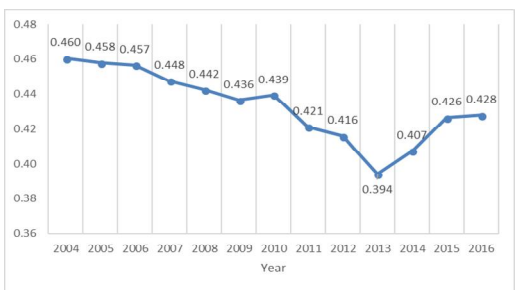

Fig. 3. Concentration ratio of the port group in Bohai Rim (2004-2016)

The HHI index of the Bohai Rim port group in the period 2004-2016 is indicated in Fig. 4. This index generally followed a fluctuation, especially in 2006 and 2013, the values of HHI recognizably suffered a significant drop, at 0.339 and 0.4, respectively. After a large decline in 2006, the year of 2007 acquired an increase to 0.36, which was followed by a stable tendency at 0.366 during the next three years. After that, a decline commenced from 2011 and bottomed at 0.34 in 2013, before gaining one more recovery to 0.354 in the last observed year. Albeit experiencing large fluctuations in 2006 and 2013 respectively, HHI index reached down from 0.368 in the beginning to 0.354 in the latest year. Evidently, this result demonstrates a trend of deconcentration with Bohai Rim port group.

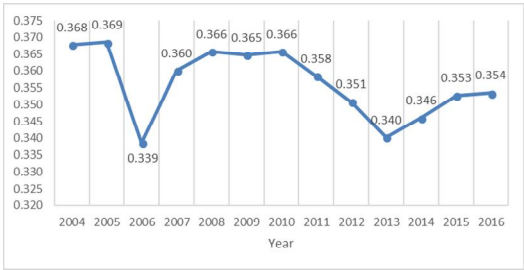

Fig. 4. HHI index of port group in Bohai Rim (2004-2016)

Additionally, Fig. 5 describes the Gini index which is comparatively visualized by the Lorenz curves in figure 6. Identically, there was also a trend of deconcentration in the Gini coefficient with the Bohai Rim port group in overview. Noteworthy that the fluctuation was such the mainstream, the peak was recorded in 2006 with 0.177 in 2006 meanwhile the year of 2014 illustrated the opposite side in only 0.34.

Regarding the Lorenz curves, the overall curves generally tended to approach close to the equality distribution line. This means the market shares were comparatively distributed balanced without significant gaps. The most equally distribution was seen in 2013, corresponded with the lowest Gini index above. A spectacular feature of the Lorenz curves, the trend of coincidence was hardly apparent due to the low distance among the indices in this period.

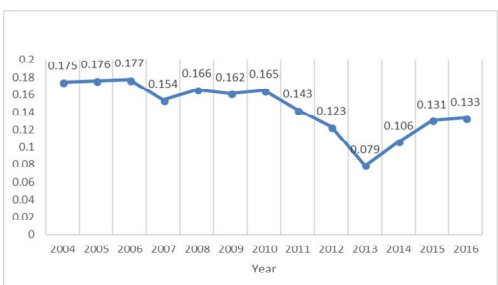

Fig. 5. The Gini coefficient index of port group in Bohai Rim (2004-2016)

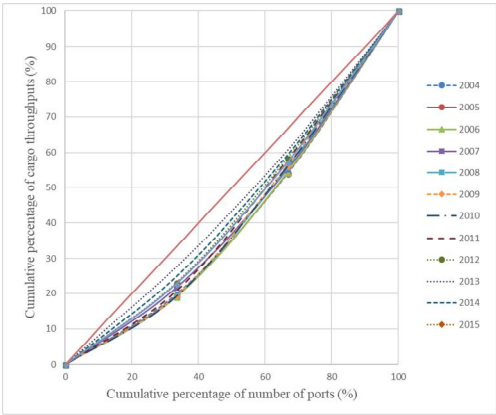

Fig. 6. The Lorenz curves of ports in Bohai Rim (2004-2016)

As an instrument to support the concentration analysis, it is necessary to access to the SSA (see Table 1). During the studied period, all the ports experienced advantageous if not disadvantageous tendency. The cargo movement, known as the shift analysis, would be focused in this study. The result indicates that during the period 2004-2016, the overall shift index of Qingdao port was -1.371 meanwhile with Tianjin and Dalian port were 0.118 and 1.252 in turn. Comparatively, Qingdao lost such amount of cargo albeit it was occupying the dominated position in Bohai Rim. In opposed, Tianjin port and Dalian port had a better performance with positive shift indices and the largest amount was recorded in Dalian. To conclude, the shift analysis pointed out a cargo movement from the largest port Qingdao and a trend of cargo captivation with Tianjin and Dalian port. Even though

Table 1. Shift-share analysis of ports in Bohai Rim

Port	Shift effect					ABSGR
	2004-06	2007-09	2010-12	2013-15	2014-16	
Qindao	-0.062	-0.264	-0.818	1.328	-1.371	12.87
Tianjin	-0.189	0.800	-0.556	0.546	0.119	10.686
Dailan	-0.128	-0.535	1.374	-1.874	1.253	7.379
Port	Share effect					ABSGR
Qindao	2.624	1.062	3.309	0.662	14.241	12.87
Tianjin	1.947	0.797	2.776	0.555	10.567	10.686
Dailan	1.129	0.513	1.444	0.463	6.126	7.379

owning the lowest market share, the overall trend was on the way up given by Dalian port in further years as expected.

5. Conclusion

After processing with the methodologies, it is concluded that there is obviously a trend of deconcentration with the port group in Bohai Rim during the period 2004-2016. In general, container throughputs in all three Bohai Rim ports followed a considerable evolution, however, suffered a slight fluctuation in certain times, for instance, in 2009 with Qingdao port and 2007-2009, 2013-2015 with Dalian port. The fluctuation is attributed to the decrease in China's export volume and the emergence of peripheral ports. In the period 2015-2016, the growth of the port group is also at a slow pace if compared with those in previous years. It can be explained by difficulties with Northeast Asia shipping routes in this time. Until 2008, the container throughput of Qingdao port reached over 10 million TEU whilst those of Tianjin and Dalian ports remained under that quantity hence, the leading position of Qingdao port is undeniable at that time. However, respectively until 2010 and 2013, Tianjin and Dalian port successfully raise their cargo volume to over 10 million TEU, which substantially impacted to the performance of Qingdao port. Especially, the highest growth rate of Dalian port is due to changes in national policy to encourage the development in this port. This analysis argues that the growth in regional influence of Tianjin and Dalian ports would motivate to the deconcentration pattern in Bohai Rim region. The deconcentration pattern shown in Bohai Rim region has noticed at container terminals in Northern Vietnam [19], and major container ports in Southeast Asia [20].

The outcomes of this study can contribute instructive references to scholars, local government decision-makers and local workers. Firstly, this study can help scholars diagnose and forecast the

development of regional ports to assist the local government in formulating beneficial decisions to facilitate such development. Additionally, the results of the concentration analysis can be projected to ports in other regions to promote their better development. In addition, this study provides concise data and conclusions, which can enable academics to portray the advantages of the ports in the studied region and conduct resource integration.

The limitation of study is very narrow research scope, only targeting 3 top container ports due to access limitations of quantitative data. In the future study, more container ports located in Bohai Rim port group are needed to include. Considering the geographic position of these three ports as the gate of northeast China, it is suggested that these three ports could explore their advantages and cooperate with the small ports in the surrounding area to enhance their influences in the future study.

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