Determinants of global logistics hub ports: Comparison of the port development policies of Taiwan, Korea, and Japan

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This paper explores global logistics hub port assessment criteria, and compares the competitiveness of three major international hub ports in Northeast Asia, namely the ports of Busan, Tokyo, and Kaohsiung, from a logistics perspective employing a hybrid multi-criteria decision-making approach incorporating the analytical hierarchy process (AHP) and gray relational analysis (GRA). A total of 20 assessment criteria are obtained under the five dimensions of political–economic environment, operating environment, cost environment, infrastructure facilities environment, and preferential incentive environment. The AHP results show that, from the perspective of all respondents, the top five assessment criteria are transport and distribution costs, convenience of customs clearance procedures, harbor and stevedoring costs, cost of land, and soundness of investment system and incentive measures. Based on GRA outcomes, Busan has the highest level of satisfaction as a global logistics hub port, followed by Tokyo and Kaohsiung.

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1. Introduction

The development of mega ships and emergence of mega strategic alliances in container shipping, including such alliances as 2M (Maersk and MSC), O3 (CMA CGM, China Shipping, UASC), G6 (NYK, Hapag-Lloyd, OOCL, APL, HMM and MOL), and CKYHE (COSCO, K-Line, Yang Ming, Hanjin and Evergreen), has changed vessel deployment patterns and port rotation schedules dramatically, and shipping companies are reducing operational costs and achieving the benefit of economies of scale by scheduling their mega ships to call at a small number of mega-hub and gateway ports. As a result, some existing hub ports on major trunk lines may be downgraded to regional ports serving only regional routes.

Driven by China’s continuing economic growth and thriving deep water ports, major trunk lines have shifted from calling on international commercial ports throughout Northeast Asia to calling exclusively on ports in China over the past decade. This trend has threatened major container ports in the leading maritime nations of Northeast Asia, such as ports of Kaohsiung, Busan and Tokyo. Fig. 1 shows the performance of major ports in China and Northeast Asia between 2001 and 2013 (Informa, 2014). Shanghai and Shenzhen enjoyed the very high average annual growth rates of 39.12% and 32.60% owing to China’s strong international trade growth. Busan and Tokyo had stable annual growth rates of 10.83% and 8.22%, while Kaohsiung had a very modest 2.31% growth rate. This data reveals that the Chinese ports have enjoyed much faster container throughput growth than the ports of Kaohsiung, Busan, and Tokyo. While the ports of Tokyo, Busan, and Kaohsiung were formerly major hubs in the region, their role is being challenged by China’s emerging ports, and how to deal with the competitive pressure from China has thus become a critical issue for Japan, Korea, and Taiwan.

Responding to the aforementioned challenge, Taiwan, Korea and Japan have implemented a series of measures to strengthen their competitiveness, including Taiwan’s 2008 I-Taiwan 12 Construction Plan, Japan’s 2006 Super Hub Port Establishment Program and 2010 International Strategic Port Plan, and Korea’s 2003 Northeast Asian Logistics Hub Port Program. These programs have sought to enhance port logistics infrastructure through measures such as port expansion, establishment of free trade zones (FTZ), and improvement of hinterland transport networks; and also to improve inefficient and unreasonable port logistics processes through logistics information system integration and specialized logistics enterprise training.

This paper investigates the major factors affecting global logistics hub ports in Northeast Asia and provides suggestions for dealing with competition issues based on a comparative analysis of port policies in Taiwan, Japan, and Korea. Because the ports of Busan, Tokyo, and Kaohsiung are the leading ports in terms of container throughput in their respective countries, we therefore
focus on these three ports, and neglect other ports in these countries. The objectives of this paper are as follows:

- To review the definitions and characteristics of global logistics hub ports.
- To determine assessment criteria for global logistics hub ports, and using these criteria to assess the competitiveness of the three mega-hub ports.
- To provide port strategy suggestions for governments and port administrators.

This study first reviewed literature concerning port choice criteria, gathered criteria frequently used in past research, and obtained industry experts’ opinions concerning the criteria via interviews. A survey of key port users and port management companies was then performed to obtain validation. The collected data was analyzed using a hybrid multi-criteria decision-making approach incorporating the analytical hierarchy process (AHP) and gray relational analysis (GRA).

2. Literature review

This section reviews literature connected with hub port selection criteria and the characteristics of global logistics hub ports in order to determine assessment criteria for global hub ports. The section also reviews and compares existing global logistics hub policies in Taiwan, Japan, and Korea.

2.1. Global hub port assessment criteria

Numerous studies have addressed port selection criteria (e.g., Tongzon, 1995, 2007, 2009; Malchow and Kanafani, 2001; Notteboom, 2004; Ugboha et al., 2006; Yu et al., 2006; Chang et al., 2008; Wong et al., 2008; Wiegmans et al., 2008; Song and Panayides, 2008; Yeo et al., 2008; Chou H. S., 2010; Chou C. C., 2010; Onut et al., 2011; Tran, 2011; Tavaszy et al., 2011; Zhang et al., 2011; Musso et al., 2013; Ahn et al., 2014; Sayareh and Rezaee Alizmini, 2014). The following is a summary of the main port selection criteria found in the reviewed literature:

- Geographic strategic location/distance: port location; maritime distance and inland distance between origin and destination. Tongzon (2007) proposed that a strategic location is critical for a logistics hub, which implies that a logistics hub port should be located on a main international shipping route.
- Physical port infrastructure: capacity of port facilities such as berths, cargo handling capacity, harbor draft, and intermodal transport facilities.
- Hinterland criteria: the location of hinterlands, extent of hinterlands, inland infrastructure facilities, hinterland connectivity, hinterland economy, cargo sources, and the proximity to consumers.
- Maritime connectivity: frequency of shipping calls, overall global services, and port accessibility.
- Costs: port fees, cargo handling charges, inland transport costs, and logistics costs.
- Operational efficiency: working time, port turnaround time, cargo handling speed, etc.
- Service quality: reliability, cargo damage avoidance credibility, quick response to users’ needs (agility), and port reputation.
- Security and safety.
- IT systems: port information services, system integration and innovation.
- Others aspects such as customs, immigration and quarantine related services.

A few studies have examined hub port competitiveness factors from an international logistics perspective. In addition to the aforementioned factors of strategic location and port infrastructure and service level, efficient hinterland systems and integration of port logistics functions are also considered key elements of a logistics hub port’s competitiveness.

- Efficient hinterland systems: port service, hinterland conditions, availability, convenience, logistics costs, regional centers, and connectivity (Yeo et al., 2008). Yu et al. (2006) proposed that cargo sources are an essential factor; Zhang et al. (2011) argued that the port hinterland economy is a decisive condition for the development of port logistics, and has a direct positive correlation with the level of cargo flow.
- Port logistics integration: information and communication technology (ICT), relationships with shipping companies, value-added services, inland transport links, relationship with inland carriers, and channel integration practices and performance (Song and Panayides, 2008).

Ports are maritime logistics centers at the interface of land and sea, and provide logistics services meeting customers’ needs. The transformation of a port into a logistics center requires space for logistics enterprises either within the port or adjacent to the port. The development of Free Trade Zones (FTZs) in the port hinterland is a common means of enhancing the ability of international container ports to provide value-added logistics services. As mentioned previously, Taiwan, Korea, and Japan have planned or are establishing FTZs within port hinterlands in order to promote their major container ports as regional logistics hubs and boost their national economies.

The presence of relevant business and logistics activities in a
ports in the Taiwan Area (2012–2016). TIPC is responsible for managing the ports of Kaohsiung, Busan and Tokyo, including strategies associated with port logistics costs, investment incentives, and customs clearance procedures.

2.2. Review of hub port policies

This section reviews relevant government port policies for the ports of Kaohsiung, Busan and Tokyo, including strategies associated with port logistics costs, investment incentives, and customs clearance procedures.

2.2.1. Port of Kaohsiung

Relevant government hub port policy measures in Taiwan have included the 1995 Asia-Pacific Regional Operations Centre project (APROC), the 2002 Global Logistics Development Plan (GLP), and the 2003 Free Trade Zone Plan (FTZP). The government of Taiwan has also undertaken very ambitious economic development campaigns under its six-year national development plans, which have been implemented since 1991. In the wake of the government’s promulgation of the “Act for the Establishment and Management of Free Trade Zones” (Taiwan’s “FTZ Act”) in July 2003, the establishment of free trade zones in Taiwan was listed as an important effort by the “Challenge 2008—Six-Year National Development Plan” and included among the “I-Taiwan 12 Projects.” The FTZ Act is intended to foster the development of new international logistics operating models and management schemes, accelerate trade liberalization, enhance national competitiveness, and facilitate national economic development.

The main goals of free trade zone development in Taiwan are to extend the current functions of the Global Logistics Development Program, cope with intense external competitive pressure (specifically from China, Hong Kong, Singapore, Japan, and Korea), deregulate current operating procedures for transshipment and re-export after processing, and realize the economic potential of seaport and airport hinterlands. The essential characteristics of a free trade zone include simplified business transaction procedures, free flow of commodities within the FTZ, exemption from customs administration and customs clearance procedures, 72-h landing visas for foreign persons engaging in business activities within the FTZ, and other preferential measures. However, the decade-long “Global Logistics Center in the Asia-Pacific Region” initiated by the government in 2000 focused on port infrastructure investments, but lacked appropriate integration of projects, and therefore achieved only limited performance gains.

In 2013, the Executive Yuan (the highest administrative organization of the central government in Taiwan) approved the first phase of the Council for Economic Planning and Development’s plan for establishing free economic pilot zones (FEPZs) in Taiwan. To generate broader economic benefit, the zones will employ “Inside the Border but Outside of Customs” and “Store in Front, Factory in Back” business models to link the zones with nearby industrial parks and local businesses. During the first phase, the FEPZs will focus on, among other areas, intelligent logistics, international medical services, value-added agriculture, and industrial cooperation. Any high-potential industries suitable for liberalization and internationalization may also be considered for inclusion inside the FEPZs.

In the wake of the 2012 port authority privatization policy, maritime administration in Taiwan includes both administrative supervision and operations. The mission of the Maritime and Port Bureau (MPB), which is under the Ministry of Transportation and Communications (MOTC), now includes the nation’s maritime and port administration affairs, and the MPB’s former authority over Taiwan’s several harbor bureaus has been reassigned to the new Taiwan International Ports Corporation (TIPC). TIPC’s four subsidiaries include the former port authorities of Keelung, Taichung, Kaohsiung and Hualien. TIPC is responsible for managing the ports as a whole, enhancing operational efficiency and responsiveness, boosting the international profile of Taiwan’s international commercial ports, and promoting domestic regional economic growth.

Kaohsiung Port was the world’s 13th largest container port and Taiwan’s largest international commercial harbor in 2012. In addition to serving as a container transshipment hub port, Kaohsiung is also the hub port in Taiwan for the import and export of bulk cargo. The Comprehensive Development Plan for International Ports in the Taiwan Area (2012–2016), which was approved on June 20, 2011, provides the following incentive measures for shipping companies in possession of dedicated container terminals at the port of Kaohsiung:
• Overall container handling capacity: (1) Annual handling volume in excess of 330,000 TEU enables the waiver of $90,000 in rental costs. (2) Attainment of additional volume targets (450,000–200,000,000 TEU handling capacity) allows the reduction of rental costs by 5–11%.

• Transshipment cargo: An increase in transshipment cargo of 10,000 TEU or more compared with the previous year enables a company to enjoy a $90,000 reduction in rental costs. Rental expenses can be further reduced by $15,000–$24,000 if transshipment cargo increases by 50%–80%.

• Dedicated container terminals outside the port area enjoy a reduction in land use fees of roughly 40%.

• Other incentives include such as a 30% reduction in charges for tug boats working at night, a 40% reduction in anchorage charges for ships of over 60,000 t, and anchorage expense reductions and container handling expense concessions when the number of ships from a shipping company increases by 90% compared with the previous year.

2.2.2. Port of Tokyo

The goal of Japan’s 2006 so-called “super-hub port policy” was to reduce costs and improve service to the same level as that of other chief Asian ports within three to five years. This initiative included: (1) reduction of harbor costs by 3%, putting them on the same level as those of the ports of Busan and Kaohsiung; and (2) reduction of service lead time from 3–4 days to one day, achieving the service level of the port of Singapore. Some major measures of Japan’s super-hub port policy relevant to the development of global logistics hub ports are as follows:

• Construction of new-generation container terminals: So-called new-generation container terminals, which represent a response to the trend toward larger ships, consist of terminals with a berth length of 1000 m, land width of 500 m or more, and an alongside depth of ~16 m.

• Establishment of port logistics hubs: Japan seeks to establish logistics hubs in its container terminals’ port hinterlands in order to provide processing and high-value-added logistics functions and reduce intermediate transport processes, shorten lead time, decrease transportation costs, strengthen international competitiveness, and ease environmental burden. With regard to foreign global terminal operating companies, such as PSA Corporation, Hutchison Whampoa, etc., if a stevedoring company operates a large-scale container terminal that is approved by port management, the Japanese government provides the following incentives: (1) In accordance with the National Property Act and the Local Government Act, companies shall be granted rental terms for a maximum of 30 years on container quay and terminal space. (2) When a terminal operator establishes gantry cranes and equipment facilities in a container terminal, the government permits the operator to use 80% of its funds without interest within 20 years as a financing repayment period. (3) Equipment and facilities enjoy a 50% reduction in fixed assets tax and city planning tax.

The Port of Tokyo provides the following incentives connected with the “super-hub port policy”: (1) Gantry crane usage fee: If container handling volume increases compared with the previous year, the increment of increase is eligible for a 50% reduction in gantry crane usage fees. (2) The increment of increase above the existing container volume will enjoy a roughly 30% reduction in port entering charges, mooring, and unmooring charges. (3) Larger ships calling on the port and coastal container transport vessels enjoy a 50% reduction in port facility usage fees. (4) Transshipment cargo handling vessels enjoy a 50% reduction in gantry crane usage fees. (5) During the first year after opening a new shipping route, import entering charges are reduced by 50%.

In accordance with the two principles of “selection and concentration” and implementation of “new growth strategies,” the June 18, 2010 meeting of the Japanese Cabinet resolved to strengthen and maintain main trunk lines in order to serve cargo concentrations throughout a wide area and achieve cost reductions. This meeting designated Hanshin Port (the port of Osaka and Kobe) and Keihin Port (the port of Tokyo, Yokohama, and Kawasaki) as “international container strategic ports” (MLIT harbor Bureau, 2011). The plan for the Keihin port includes the following main items:

• The container handling volume of the port will be increased from 7 million TEU in 2011 to 10 million TEU in 2015, which will maintain its status as the main port in east Japan, make it a hub port able to compete with Korea’s Busan port, and finally achieve the goal of being a leading hub port in East Asia.

• Reduction in container terminal operating costs, reduction in leasing costs, and support in improving container terminal productivity.

• To improve the cargo collection system, subsidies are provided for construction of ships operating on domestic feeder routes, and exemption provided from oil and coal tax. In the case of trucks, the government has established a metropolitan expressway discount system and embarked on early improvement of designated highways.

• The government provides subsidies to ensure a ~18 m depth alongside of quay walls.

• Establishment of an integrated special zone system at Keihin port. The so-called “integrated special port zone” means that, after designation by the Ministry of Transport, this zone serves as a demonstration area promoting a series of port reform measures aimed at enhancing operating flexibility and competitiveness, and is not governed by the same commercial port laws and regulations as other Japanese ports.

2.2.3. Port of Busan

Korea’s “logistics hub strategy in the Northeast Asia” includes both regional and global perspectives. The former refers to the port’s role within the Northeast Asian region, and calls for the port of Busan to be a regional cargo handling center, as well as an intermediate transshipment port for Russia, Southeast Asia, and other countries. With a global perspective in mind, Korea hopes that its airports, ports, and hinterland can provide neighboring countries with a base for logistics and related service functions. In order to improve the international competitiveness of the Korean economy, Korea hopes to recruit logistics-related foreign companies to promote value-added logistics.

Korea’s Northeast Asian logistics hub strategy was initiated in April 2003, and calls for the development of the ports of Busan and Gwangyang, and their hinterlands, as “a gateway to Northeast Asia for the world’s goods, information, and people.” This strategy’s chief initiatives can be roughly divided into the following three aspects:

• Busan Port and Gwangyang Port are to construct hub ports for Northeast Asia through port development and construction, as well as via expansion of their hinterland and inland transport facilities.

• Reliance on logistics information system integration and specialized logistics enterprise training to strengthen competitiveness.

• Expansion of maritime cooperation among Korea, China, and Japan, and reliance on Korean railways, Chinese land bridge, and Siberian railway land bridge links to further develop transport logistics networks in Northeast Asia.
In order to construct a high-value-added logistics hub, and strengthen Busan Port’s position as a leading container hub port in Northeast Asia, the number of container terminals will be increased to 17 with larger container berths and six with feeder berths, dock depth will be dredged to –17 m, and logistics space and hinterland access transport networks developed. Busan port is located on major trunk routes serving the world’s factory—China—and the world’s second largest market—Japan. This port, with 368 weekly liner visits and connections to over 500 ports, handles around 8.6 million TEU of international transshipment cargo every year, and had a transshipment container ratio of 49.5% in 2013.

Due to intense competition between ports in Northeast Asia and need to attract transshipment containers, many ports in the region have been offering a variety of incentives, and Busan port has implemented an incentive system since January 2004. In comparison with neighboring ports, after calculation of transshipment incentives based on annual transshipment handling volume, Busan port’s transshipment costs are quite competitive. Busan port extended the scope of incentives to small and medium sized shipping companies in 2007 and coastal shipping companies in 2009.

In addition, Busan port has implemented the following series of measures:

- Handling charge reduction: Busan port’s handling charges have been reduced from the original 5–6 million won to only 30,000 won; Gwangyang Port’s handling charges are 60% lower than those of Busan port.
- A reduction in ship port charges in order to encourage shipping companies to open up new routes.
- When foreign enterprises and foreign investment account for more than one percent of a joint venture, a company may rent land for a period of fifty years with an annual rent of 0.8 dollars per square meter; this rate is only one-fifteenth of that in Shanghai.

2.2.4. Comparison of global hub port policies of Taiwan, Japan, and Korea

A few points regarding the global hub port policies of Taiwan, Japan, and Korea are discussed as follows:

- Port governance models differ in Japan, Korea and Taiwan (see Table 1). Japan implements a municipal port model. In the case of Tokyo, the Tokyo Metropolitan Government owns the port and the port authority, Bureau of Port and Harbor, is a department of the Tokyo Metropolitan Government. As a consequence, port development strategies must be approved by the Metropolitan Government. Korea employs an autonomous port authority model, and the Busan Port Authority is governed by the Korean Ministry of Maritime Affairs and Fisheries. As for Taiwan, the Taiwan International Ports Corporation (TIPC) is under the control of the Ministry of Transportation and Communications (MOTC), and both TIPC and the MOTC must propose port development projects to the central government so that the government can examine project feasibility and grant approval for project implementation.

- A review of the ports’ container handling throughput growth from 2001 to 2013 sheds light on the impact of port policies on container handling performance among Taiwan, Korea, and Japan. The fact that Busan port had the highest annual growth rate (10.83%), followed by Tokyo port (8.22%) and Kaohsiung port (2.31%), suggests that Busan’s port policies, including the strategy of transforming the port into a logistics hub for Northeast Asia, may have a greater positive impact on port performance than policies undertaken at the other rival ports. It is notable that Busan port’s high annual growth rates were achieved by not only increasing import and export containers, but also boosting the volume of transshipment containers. This is evidenced by the fact that the transshipment rate of the port of Busan has increased from 19.30% in 2000 to 50.47% in 2014 after the port introduced incentive measures for shipping companies in 2001 (Ministry of Maritime Affair and Fisheries, 2015).

- The government of Taiwan has established Free Trade Zones (FTZs) at international container ports, and this policy also includes the simplification of business procedures and promotion of the free flow of goods within the FTZ, exemption from customs administration and customs clearance procedures, and other preferential measures (Taiwan International Ports Corporation, 2012). In line with the Super Hub Port Establishment Program and International Strategic Port Plan, Japan’s international container ports have endeavored to reduce costs and improve service by providing users with fee reductions and measures facilitating improvement of operational efficiency. In addition, the planned establishment of integrated special port zones at the Port of Keihin (port of Tokyo, Yokohama, and Kawasaki) will enhance operational flexibility and competitiveness (MLIT Harbor Bureau, 2011). The Korean government’s Northeast Asian Logistics Hub Port Program has expanded infrastructure and superstructure, made improvements to berths/terminals and logistics spaces, and improved hinterland access through a better inland transport network at the country’s two major container ports, namely the ports of Busan and Gwangyang (Ji, 2012). All of these strategies have attempted to enhance port logistics infrastructure (software and hardware), improve efficiency, and reduce the cost of port logistics processes, and have the ultimate goal of creating global logistics hub ports.

3. Methodology

A review of recent literature associated with port selection reveals that a number of research approaches have been employed to explore port selection determinants, including exploratory factor and confirmation factor analysis (Chang et. al., 2008), a multinomial logit model (Nir et al., 2003), regression analysis (Tongzon, 2009), a

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<th>Table 1</th>
<th>Comparison of global hub port policies in Taiwan, Japan, and Korea.</th>
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mathematical algorithm (Tran, 2011), a discrete choice model (Malchow, 2001; Malchow and Kanafani, 2004), and an equilibrium model (Tally and Ng, 2013). Some studies have adopted simple multi-criteria decision-making approaches in assessing the impact of other factors on port selection decisions, including an analytic hierarchy process approach (Ugboma et al., 2006) and fuzzy analytic hierarchy process approach (Onut et al., 2011; Chou H.S., 2010; Chou C.C., 2010). In addition, a number of hybrid research approaches have been adopted by some researchers, such as a combined AHP and a fuzzy ratio assessment model (Wang et al., 2014a, 2014b; Zavadskas et al., 2015), fuzzy and TOPSIS models (Wang et al., 2014a, 2014b), and entropy and WASPAS methods (Bagocius et al., 2013).

Multi-criteria decision-making methods can be employed to identify quantitative or qualitative evaluation criteria, and the AHP and GRA methods have been increasingly applied to academic research in recent years. Pophalie et al. (2011) suggested that AHP and GRA are powerful tools which can be used to determine appropriate alternatives in multiple objective decisions. Lin and Hsu (2003) used AHP to identify Internet advertising networks. Ma et al. (2011) employed AHP and GRA to perform network and terminal selection. Lu and Liu (2014) applied AHP and GRA to find determinants of air transport service expansion across the Taiwan Strait.

This study used a hybrid multi-criteria decision-making approach consisting of the analytic hierarchy process (AHP) and gray relational analysis (GRA) to resolve complex port selection issues. The AHP approach is employed to determine the relative weights of global logistics hub port assessment criteria gleaned from a review of the literature and interviews with experts from shipping companies, global logistics companies, and port management companies in Taiwan. GRA is used to identify the ranking order of global hub ports in Northeast Asia (the ports of Kaohsiung, Busan, and Tokyo) based on relative importance of the assessment criteria as determined using AHP. In terms of questionnaire design and calculation procedures, this hybrid decision-making approach was simpler than using traditional AHP alone.

As AHP is a very common and popular analytical approach used in academic research, the following section merely explains the GRA method.

### 3.1. Gray relational analysis

Gray relational analysis (GRA) was proposed by Julong Deng in 1982 as an extension of gray theory, which had already been shown to be a simple and accurate method for solving decision-making problems with multiple attributes (Tang and Chen, 2012). Gray system theory offers the advantages of minimal data requirements, simplicity of use, and reasonable expected results (Lin and Wu, 2011), while GRA involves first translating the performance of all alternatives into a comparability sequence. The gray relational method is a data processing method used to determine the degree of correlation between influencing factors in a system with uncertain information (Deng, 1989). To overcome the restrictions of small sample size, gray relational analysis can be used to group initial evaluation indicators and select the most representative indicators (Wen et al., 2006). This paper provides a brief overview of the gray relational grade formula proposed by Deng (2000) as follows.

Gray relational coefficient

\[ \gamma(x_0(k), x_i(k)) = \frac{\Delta_{min} + \xi \Delta_{max}}{\Delta_{min} + \Delta_{max}} \]

where

(a) \( i = 1, 2, 3, ..., m \), \( k = 1, 2, 3, ..., n \), \( j \in i \)

(b) \( x_0 \): reference sequence.

(c) \( x_i \): inspected sequence.

(d) \( \Delta_{min} = \min \{ k(x_0(k) - x_i(k)) \} \)

(e) \( \Delta_{max} = \max \{ k(x_0(k) - x_i(k)) \} \)

(f) \( \xi \): distinguishing coefficient, \( \xi \in [0,1] \)

Since the weights of different factors are not equal, we can expand the foregoing equation to:

\[ \gamma(x_i, x_j) = \sum_{k=1}^{n} \beta_k \gamma(x_i(k), x_j(k)) \]

where \( \beta_k \) is the weight of each factor, and \( \sum_{k=1}^{n} \beta_k = 1 \)

### 3.2. Assessment variables

The assessment factors for global logistics hub ports used in this paper were determined through the following process. First, we selected assessment factors appearing more than twice in the literature discussed above, and these selected factors were then confirmed by six experts at shipping companies (including executives or managers at APL and OOCL), logistic companies (Evergreen logistics and NYK logistics) and a port management company (Taiwan International Ports Corporation and its Kaohsiung Harbor Branch). A total of 20 assessment criteria were selected and classified under five dimensions of political-economic environment, operating environment, cost environment, infrastructure facilities environment, and preferential incentive environment (see Table 2).

### 3.3. Data collection

This study sought to determine the importance of global logistics hub port assessment criteria as perceived by shipping companies, logistics companies (port users), and port companies (port managers), and also to assess the extent to which the three international hub ports in Northeast Asia meet these assessment criteria. Questionnaires were distributed to international container shipping companies calling at Taiwan’s ports, logistics companies, and the managers of the Taiwan International Ports Corporation at the port of Kaohsiung. After receiving the returned questionnaires in July 2013, this study performed data analysis using a hybrid multi-criteria decision-making approach, and obtained the ranking order of the three mega-hub ports in Northeast Asia in terms of their suitability as global logistics hub ports.
4. Empirical analysis

4.1. Analysis of respondents’ backgrounds

A total of 30 questionnaires were distributed to 10 experts at shipping companies, 10 experts at logistics companies, 10 experts at port companies, and 10 experts at shipping companies and logistics companies; 44% of the respondents held the position of general manager, and 32% were managers or vice managers. In terms of working experience, 44% had 16–20 years’ experience or more, 24% had 11–15 years, 16% had 21–25 years. The respondents’ positions and experience suggested that their opinions were competent and representative. Additionally, in line with Robinson’s (1980) suggestion that five to seven experts are suitable for group decision-making, the validity and representativeness of the sample should be acceptable in this survey (refer to Table 3).

4.2. AHP analysis

The consistency ratio (C.R.) of the hierarchical structure was examined using AHP. Table 4 shows that the consistency ratio of the five dimensions ranged from 0.00 to 0.03. As the overall consistency ratio of 0.01 was lower than 0.1, the survey results were considered valid and consistent. Furthermore, AHP was used to calculate the weights of the five assessment dimensions and 20 assessment criteria based on the respondents’ opinions of the relative importance of the various assessment dimensions and criteria. An overall weight for each assessment criterion was then obtained by multiplying the weight of the individual assessment criterion and the weight of its corresponding dimension. Finally, the overall weights were ranked.

This study used the AHP method to calculate the weights of the five assessment dimensions and 20 assessment criteria based on the
respondents' opinions concerning relative importance of the various assessment dimensions and assessment criteria. The weight of each dimension was then multiplied by the weights of the individual evaluation factors under that dimension to obtain the overall weight for that dimension. Table 5 contains the overall weights of dimensions and assessment criteria from the viewpoint of all respondents.

As shown in Table 5, Cost Environment has the highest weight of 0.284, followed by Preferential incentives environment (0.210), Operational environment (0.194), Infrastructure facility environment (0.169) and political–economic environment (0.142). The top five assessment criteria were effectiveness of port logistics facilities (0.093), convenience of customs clearance procedures (0.075), harbor and stevedoring cost (0.071), cost of land (0.067), and soundness of investment system and incentive measures (0.063). These results revealed that political–economic environment was the least important dimension, and contained lower-ranking assessment criteria. In the following discussion, we therefore focus on main critical issues related to the top four dimensions, namely Cost Environment, Preferential Incentive Environment, Operating Environment and Infrastructure Facilities Environment.

4.2.1. Cost environment problems

The cost environment was considered as the most important dimension by all respondents, and transport and distribution costs were recognized as the most important assessment criterion by all respondents. For example, Japan initiated its “super-hub port policy” in 2006 in an attempt to reduce costs to the same level as those of other major Asian ports. This is because container handling charges at port of Tokyo had previously been higher than those at Kaohsiung and Busan ports by about one third (The Ministry of Land, Infrastructure, Transport and Tourism, 2014). Japan has the highest charges because of its higher labor costs and monopoly control of container terminal operations. In contrast, the Korean government subsidized the port of Busan to reduce costs, and Kaohsiung port has relatively low labor costs, so costs are lower. The advantage of lower costs can be seen from the fact that carriers in the western part of Japan prefer to perform transshipment via Busan port because transshipment costs at this port are only one-third of those at the Hanshin port (port of Osaka and Kobe). As a consequence, in light of the dynamic situation in the shipping market, port authorities and port management companies must constantly review port and cargo handling charges, and establish prices that are competitive with those of neighboring hub port rivals in same region.

4.2.2. Preferential incentive environment

Based on factor analysis, Yeo et al. (2008) suggested that hinterland-related aspects, such as the size and activity of a free trade zone, are critical port selection factors. Chou (2010) proposed that free trade zones are one of the critical assessment criteria for container transshipment hub locations after performing a comparison of the ports of Kaohsiung, Hong Kong, and Shanghai. In the wake of the establishment of free trade zones in 2003, the tenant companies have enjoyed cheaper land rental fees and higher stevedoring revenue, and the port management company can provide companies with special terminal rent relief measures. Nevertheless, the taxation system should be modified to allow longer storage time in FTZ warehouses without custom duty regulation restrictions, which will facilitate cargo distribution. In addition, in order to boost their willingness to make investments, tenant companies should be able to apply for various preferential measures, including special corporate tax relief or reduction and duty-free import of equipment for the companies’ own use. Owing to the importance of incentive measures in attracting FTZ investment, this paper therefore includes investment incentive environment as one of the assessment dimensions of a logistics hub port. This finding reveals that preferential incentive measures are important to a logistic hub port, as evidenced by the fact that the soundness of investment system and incentive measures was ranked fifth, and exemption from and reduction of custom duties and value-added tax for cargo and exemption from and reduction of corporate and local taxes were ranked seventh and eighth.

4.2.3. Operating environment

The majority of respondents expressed that the administrative procedures needed when applying for customs clearance are very troublesome because many inconsistent intermediate processes and services from different sources are needed, and the result will be delays in customers’ shipments. It should be noted that, in order to ensure global supply chain security, the US customs authority has requested Taiwan’s custom authority to sign a CSI (Container Security Initiative) MOU and stationed an American CSI team in Kaohsiung port. CSI requirements have affected container inspection processes and the document examination period for shippers and maritime service providers in Taiwan when
exporting and transshipping cargoes to the US. As complicated customs clearance procedures sometimes delay shipments, the custom authority in Taiwan has reduced the inspection ratio for inbound and outbound containers, and has also simplified administrative procedures through the use of single-window service, which aims to achieve the goal of rapid cargo shipment and prompt delivery.

4.2.4. Infrastructure facilities environment

Shipping companies considered Infrastructure Facility Environment as the most important factor in assessing a global hub port. For example, container terminal six, which is an automated container terminal operated by Yang Ming line since 2011, does not yet have a dedicated road connecting with a local highway, and container tractors must therefore pass through city roads, which has led to long transportation times and late deliveries when traffic congestion is encountered. Personnel in the industry therefore recommend that the government build a dedicated road providing direct access to the highway in order to resolve this serious transport problem, and it is estimated that a dedicated road can cut transport time by approximately 40 min in comparison with the existing situation. When Busan port confronted a similar problem ten years ago, the port authority and government constructed several dedicated roads allowing container truck movement without entering the city, which resolved the problem of traffic congestion. Construction of a dedicated road providing direct access to the freeway is therefore considered a necessary means of facilitating timely transport.

4.3. GRA analysis

In implementing gray relational analysis, this study first used the data to calculate the mean values of all respondents’ degree of satisfaction toward each assessment criterion, normalized the degree of satisfaction of each criterion, and then used the normalized values to perform difference series calculations. The GRA formula was finally employed to obtain GRA coefficients, and GRA grades were calculated from the GRA coefficients multiplied by the AHP weights, allowing the ranking order of the three hub ports in East Asia to be determined based on their GRA grades.

The following example of GRA calculation procedures is provided to clarify this study’s analytical steps (see Table 6):

1. Mean value: The paper collected raw data concerning the degree of satisfaction toward assessment criterion A1 (Stability of political climate); the mean value of A1 from the viewpoint of all respondents was 3.54.
2. Normalized value: The mean value was used to calculate a normalized value based on judgment of the asked value or worst value. Since A1 constitutes the asked value, and larger is better, we chose asked value’s normalized value, 3.54/MAX (3.54, 3.58, 4.17) = 0.85.
3. Difference value: The difference value was calculated employing the reference value \((0.510*0.030=0.015)\) and the normalized value \((x(j))\) of the reference value of A1.
4. GRA coefficient: Based on algorithmic formulas (1) and (2), \((\text{MIN} (0.00, 0.00, 0.00)+0.587*0.058+0.384*0.032) = 0.510\), where the identified value relative to \(\zeta\) is 0.5.
5. GRA grade: Based on algorithmic formula (3), we first calculate the GRA grade of the port of Kaohsiung using the individual assessment factor (i.e., A1), which is 0.510 (GRA value) \(*0.030\) (AHP weight) = 0.015; we can now calculate the GRA grades for all assessment criteria for the port of Kaohsiung, which are summed to determine the GRA grade of the port of Kaohsiung from the viewpoint of all respondents.

\[\frac{\sum (0.510*0.030+0.477*0.047+\ldots+0.587*0.058+0.384*0.032)}{0.616}\]

The results show that Busan elicited the highest satisfaction as a regional global logistics hub port from the respondents, and was followed by Tokyo and Kaohsiung. Among the 20 criteria, Kaohsiung had GRA grades greater than those of Busan and Tokyo for only four criteria (i.e. cost of labor, cost of land, harbor and stevedoring costs, and transport and distribution costs). It is worth noting that respondents from all three surveyed groups shared the

<table>
<thead>
<tr>
<th>Assessment criteria</th>
<th>Kaohsiung</th>
<th>Busan</th>
<th>Tokyo</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability of political climate</td>
<td>0.510</td>
<td>0.527</td>
<td>1.000</td>
<td>0.030</td>
</tr>
<tr>
<td>Economic scale of market</td>
<td>0.477</td>
<td>0.927</td>
<td>1.000</td>
<td>0.047</td>
</tr>
<tr>
<td>Volume of transshipment cargo</td>
<td>0.363</td>
<td>1.000</td>
<td>0.333</td>
<td>0.037</td>
</tr>
<tr>
<td>Deregulation of international trade and foreign currency exchange systems</td>
<td>0.407</td>
<td>0.716</td>
<td>1.000</td>
<td>0.027</td>
</tr>
<tr>
<td>Efficiency of local government administration</td>
<td>0.402</td>
<td>0.679</td>
<td>1.000</td>
<td>0.029</td>
</tr>
<tr>
<td>Convenience of customs clearance procedures</td>
<td>0.435</td>
<td>1.000</td>
<td>1.000</td>
<td>0.075</td>
</tr>
<tr>
<td>Efficiency of port and logistics operations</td>
<td>0.620</td>
<td>1.000</td>
<td>0.746</td>
<td>0.044</td>
</tr>
<tr>
<td>Integration of customs and port logistics information</td>
<td>0.516</td>
<td>1.000</td>
<td>0.046</td>
<td>0.046</td>
</tr>
<tr>
<td>Cost of labor</td>
<td>1.000</td>
<td>0.636</td>
<td>0.370</td>
<td>0.053</td>
</tr>
<tr>
<td>Cost of land</td>
<td>1.000</td>
<td>0.776</td>
<td>0.483</td>
<td>0.067</td>
</tr>
<tr>
<td>Harbor and stevedoring costs</td>
<td>1.000</td>
<td>0.730</td>
<td>0.558</td>
<td>0.071</td>
</tr>
<tr>
<td>Transport and distribution costs</td>
<td>1.000</td>
<td>1.000</td>
<td>0.624</td>
<td>0.093</td>
</tr>
<tr>
<td>Effectiveness of port logistics facilities</td>
<td>0.463</td>
<td>1.000</td>
<td>0.830</td>
<td>0.042</td>
</tr>
<tr>
<td>Adequacy of the port hinterland for logistics functions</td>
<td>0.350</td>
<td>1.000</td>
<td>0.700</td>
<td>0.030</td>
</tr>
<tr>
<td>Efficiency of intermodal transport network</td>
<td>0.433</td>
<td>0.935</td>
<td>1.000</td>
<td>0.035</td>
</tr>
<tr>
<td>Sailing frequency and diversification of shipping routes</td>
<td>0.512</td>
<td>1.000</td>
<td>0.816</td>
<td>0.062</td>
</tr>
<tr>
<td>Soundness of investment system and incentive measures</td>
<td>0.431</td>
<td>0.930</td>
<td>1.000</td>
<td>0.063</td>
</tr>
<tr>
<td>Exemption from or reduction of corporate and local taxes</td>
<td>0.444</td>
<td>1.000</td>
<td>0.810</td>
<td>0.057</td>
</tr>
<tr>
<td>Exemption from and reduction of custom duties and value-added tax for cargo</td>
<td>0.587</td>
<td>1.000</td>
<td>0.927</td>
<td>0.058</td>
</tr>
<tr>
<td>Financial assistance for investing companies</td>
<td>0.384</td>
<td>1.000</td>
<td>0.686</td>
<td>0.032</td>
</tr>
<tr>
<td>MAX value</td>
<td>0.289</td>
<td>0.140</td>
<td>0.312</td>
<td></td>
</tr>
<tr>
<td>MIN value</td>
<td>0.616</td>
<td>0.904</td>
<td>0.770</td>
<td></td>
</tr>
<tr>
<td>GRA grade</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
view that the port of Kaohsiung was the least satisfactory choice as a logistics hub port. This result implies there is an urgent need for the port to improve in order to retain a competitive advantage in the region.

Since the hub ports in Taiwan, Korea, and Japan face intense competition from Chinese ports, which enjoy ample container throughput, the governments of these three countries have assigned port development budgets and resources to support port construction projects as specified in each country’s port master plan. The majority of these government resources have been used to aid hub port development in an effort to achieve higher performance. For instance, in view of the fact that Busan port’s container handling volume accounts for 70% of overall container handling volume in Taiwan, the government of Taiwan has endeavored to provide funding to develop the deepest-depth container terminals I and II at the port in accordance with the 2008 I-Taiwan 12 Projects. In contrast, in line with the national port development master plan and port status, small ports such as the ports of Taichung and Keelung have obtained much smaller shares of funding for port construction projects.

This situation is similar to that of the port of Busan, which handles 75% of overall container volume in Korea. Due to its critical role in container handling throughput and the national port development master plan, the Korean government provides 100% of the budget for construction expenses at Busan port. In contrast, in spite of its location adjacent to Seoul, Incheon port obtains only 50% of its port infrastructure construction budget from the government. In addition, due to restrictions on shipping routes and transport capacity under the navigation rights agreement signed by Korea and China, Incheon port does not enjoy as much freedom in opening shipping routes as the ports of Busan and Gwangyang. As a result, 65% of import cargo to the Seoul area originating from Chinese ports is shipped via Busan port, Gwangyang port, and other domestic ports. This policy is similar to Japan’s “selection and concentration policy,” which has strengthened main trunk lines as a means of reducing costs and gathering cargo from wider areas. Under this policy, Hanshin Port (port of Osaka and Kobe) and Keihin Port (port of Tokyo, Yokohama, and Kawasaki) have been designated strategic international container ports.

### 5. Conclusions and implications

The empirical results of this study include the following: First, it defines a global logistics hub port as a port in a strategic geographical location at the intersection of major trunk and feeder systems, and which provides integrated value-added logistics services in addition to conventional import, export, and transit cargo operations. The main goals of a global logistics hub port are therefore to shorten lead times, reduce transportation costs, and strengthen international competitiveness. One interesting point is that transshipment cargo is considered by some logistics hub ports as an important source of container handling throughput, as suggested by Jin and Li (2007), port hinterland functions should be designed and organized in keeping with local economic and industrial development; for instance, the port of Taipei has established a car distribution park reflecting the nearby location of auto assembly lines and the high concentration of potential car buyers in northern Taiwan.

Empirical results reveal that Kaohsiung port faces serious challenges in comparison with Tokyo and Busan ports.

Third, there is currently a trend for international shipping companies to establish international logistics companies. This is because shipping companies are only responsible for sailing routes with port-to-port services, while door-to-door service must be handled by international logistics companies. For instance, Evergreen shipping has established an Evergreen logistics company. Evergreen terminal company, and Evergreen trucking company, and the Evergreen Group hopes to offer one-stop service to various shippers from an integrated supply chain perspective, such as by providing CFS to domestic or international logistics service providers.

Fourth, in order to provide integrated supply chain service to shippers around the world, shipping companies have been establishing international logistics service providers offering freight forwarding, custom brokering, container consolidation, container freight station, multi-country consolidation, multi-country distribution, and other value-added logistics activities. For instance, Yang Ming Line has established Yes Logistics, which is one of the tenants in a port-type free trade zone, and offers customers CFS with free duty, extended storage periods, and consolidation and distribution services. This company regards CFS consolidated cargo as an important source of container handling throughput.

Fifth, in order to increase port container volume, incentives can be granted to shipping companies which add the port to a new shipping route or increase sailing frequency. For example, port authorities in Japan and Korea have provided incentives including reduction of or exemption from voyage charges, wharf fees, and equipment usage fees, and even the provision of marketing assistance measures, to encourage such decisions. Ahn et al. (2014) suggested that cargo volume can be increased by providing various incentives to port container terminals and encouraging aggressive marketing by logistics companies. As for transshipment container terminals, the ports of Busan and Tokyo also provide incentive measures seeking to increase volume by targeting both ocean-going shipping companies and the coastal shipping industry. For instance, Busan port’s “Transshipment Cargo Incentive Measures” have provided a total of 12 billion Korean won to shipping companies since 2006, which has led to growth of 20.52% in transshipment cargo from 2006 to 2010 (Kim, 2011). For its part, Tokyo port offers vessels carrying transshipment cargo a 50% reduction in gantry crane usage fees, and the Japanese government also provides financing assistance for the construction of feeder vessels.

Finally, port hinterland areas play intermediary roles between ship cargo handling areas and local urban districts. In view of the cluster concept, current port-type FTZ logistics functions can be extended to multifunctional parks containing international trade and exhibition areas, logistics parks, technology R&D parks, assembly and processing parks, venture business parks, and waterfront leisure parks. The port of Kaohsiung must overcome the challenge of insufficient space in the port hinterland for implementation of integrated logistics functions. The government of Taiwan, in line with its export-driven economic policies, should place greater emphasis on promotion of integrated port hinterland development aimed at strengthening various value-added logistics functions, such as processing, assembly, and distribution. Moreover, as suggested by Jin and Li (2007), port hinterland functions should be designed and organized in keeping with local economic and industrial development; for instance, the port of Taipei has established a car distribution park reflecting the nearby location of auto assembly lines and the high concentration of potential car buyers in northern Taiwan.
References


