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Analytic Hierarchy Process Modelling of Location Competitiveness for a Regional Logistics Distribution Center Serving Northeast Asia

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Abstract

Purpose – As the global product network expands through both internationalization and diversification of the multimodal transportation system, corporate strategies have shifted to emphasize the importance of a high value-added international logistics system. To guide policies and strategies to attract relevant industries, this study aims to analyze the location competitiveness of regional logistics distribution center to serve Northeast Asia.

Design/methodology – Multi-criteria techniques are considered to offer a promising framework for evaluating decision-making factors. This paper employed an analytic hierarchy process to analyze the hierarchal structure of determinants for selecting the location of a regional logistics distribution center. Adopting both qualitative and quantitative evaluations, this study suggest political implications for a regional logistics distribution center development, such as the direction of political support, service differentiation and infrastructure development.

Findings – This study developed a location competitiveness evaluation model, based on the case study of the major port-cities in Northeast Asia. Evaluation model incorporates five factors underpinning 17 components extracted using factor analysis. The results revealed that the logistics factor is the most significant factor for evaluating the competitiveness of a regional logistics distribution center. The remaining factors were market, costs, and services environment. Comparing qualitative and quantitative evaluations, results provide useful insights for a regional logistics distribution center development in Northeast Asia.

Originality/value – This study revealed differences between qualitative and quantitative evaluations. The finding implies that prior works on evaluation models of competitiveness has not successfully measured the gap between quantitative data and expert' evaluations. To overcome this limitation, this paper considered both actual data such as actual distance, cost, the number of companies located, and expert opinions.

Keywords: Analytic Hierarchy Process, Location Competitiveness, Multi-Criteria Decision Making, Northeast Asia, Regional Logistics Distribution Center

JEL Classifications: D12, F14, O53

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1. Introduction

As globalization advances and more economies join trade blocks, corporate strategies have shifted to emphasize the importance of a high value added international logistics system focused on speed and value added services. Over time, as the global product network expands through both internationalization and diversification of the multimodal transportation system, low cost product clusters have formed at sea-ports and airports in low cost and high efficiency countries (Guo and Zhao, 2012; Kim Si-Hyun and Chiang Bong-Gyu, 2017; Notteboom, 2011). In order to build a base for a low-cost production and manufacturing network, multinational companies have sought to build global supply chains that connect providers throughout the supply chain, from raw material procurement to sales of products (Bhatnagar and Sohal, 2005). This process requires companies to devise strategies to assist in the selection of suitable locations to build bases for their logistics activities, research and development, and manufacturing in each global region. Typically, these locations are centered on major ports and airports (Cariou et al., 2015; Notteboom and Rodrigue, 2005).

Recently, competition to become the logistics center of global firms has accelerated as the overall scale of global trade has grown. All firms require an efficient logistics network that must accommodate recent global manufacturing and procurement of network expansions (Kang Dal-Won and Kim Si-Hyun, 2017). Over time, logistics centers have increasingly taken on the function of adding value in supply chains. The creation of added value occurs through the activities of assembling, processing, classifying, labelling, and packing, which now take place at a logistics center (Chen and Notteboom, 2012; ESCAP, 2002). Competition between port cities that are seeking to host an RLDC that serves Northeast Asia has intensified as the benefits associated with the role of adding value throughout the region become economically crucial. South Korea and China, recognizing the importance of port hinterlands, are competing to develop ports and port hinterlands to attract global companies to those hinterlands. In this situation, building an institutional plan to construct logistics infrastructure or to attract companies is vital. However, such planning is inevitably predicated by determination of the locational competitiveness of regional logistics distribution centers capable of serving the Northeast Asian market (UNCTAD, 2016). Surprisingly, relatively few academics have systematically studied concrete locational factors and analyzed the locational competitiveness of a potential RLDC (regional logistics distribution center).

Northeast Asia centers on South Korea, China, and Japan. These countries are geographically proximate and given their large markets, the determination of where to locate RLDC to serve Northeast Asia will increasingly shape supply chains. As companies become increasingly interested in value added logistics activities, interest in growing profits through developing logistics activity is also increasing. However, a key prerequisite relates to where to place the RLDC. Because the RLDC must serve the entire Northeast Asia area, studies are required to determine the competitiveness of each target country and city. The problem of location selection must be solved before a differentiated development strategy suited to each target area can be devised. Within the study aim of analyzing the factors that determine the selection of a location for an RLDC in Northeast Asia, this study evaluates the competitiveness of major port cities in South Korea and China as suitable locations for an RLDC in Northeast Asia, and deduces the implications of selecting each location as an RLDC to perform value added logistics activities.

The remainder of this paper is organized as follows: first, the study begins by reviewing some definitions of an RLDC and the determinants of its location. The methodology of a survey to analyze the perceived locational competitiveness of selected factors is reported. The results presented incorporate exploratory factor analysis including reliability analysis and an analytic hierarchy process (AHP). The importance of each factor is estimated and four candidate locations are evaluated both qualitatively and quantitatively. The paper concludes by considering the implications for promoting competitiveness.

2. Literature Review

2.1. Regional Logistics Distribution Center

A distribution center has been defined as "the warehouse facility which holds inventory from manufacturing pending distribution to the appropriate stores" (Vitasek, 2012, 61). With the increased importance of distribution centers in logistics activities, their functions have changed (Bolten, 1997). For example, the logistics systems in the 1960's and 1970's distribution centers hosted simple logistics activities focused on exports. Basic receiving functions have remained relatively unchanged, as have order processing, picking, order assembly, palletization and unitization, labelling, marking and stenciling. As local subsidiaries grew based on more complex local logistics systems in the 1980's and 1990's, the support functions of distribution centers also grew. Storage later became associated with inventory management as well as control and shipment scheduling functions. Electronic Data Interchange reporting was required, along with bonding, import clearance and inbound transportation. Eventually materials management and distribution services at national and global levels were required. Complex outbound transportation services now require export documentation, carrier selection, freight rate negotiation, claims handling, performance measurement, customer invoicing and many other services. In short, distribution centers have developed into strategic logistics bases that serve their local economy and present a logistics hub in a system driven by supply chain management (Hilmola and Lorentz, 2010).

Today's distribution center is a significant component of international shipping and economic cooperation with its surrounding areas, integrating the overall production and distribution systems referred to as value adding logistics services (Kim Si-Hyun, Dinwoodie and Kang Dal-Won, 2016; Yang Hang-Jin et al., 2019). The functions of a distribution center vary from a warehouse for inventory to a multi-functional logistics center (Ashayeri and Rongen, 1997). Particularly, value adding logistics services encompass far more roles and functions than existing services. In many cases, these services overlap and may include third-party services, such as inventory management, inspection, labelling, packing, barcoding, order picking, returns, customized services and reverse logistics. The demands for value adding logistics services in the logistics chain of supply chain management stimulated the emergence of RLDCs which function as a regional gateway beyond a port's hinterland (ESCAP, 2002). In accordance with this trend, the RLDC has become a critical component for linking elements in the supply chain management more efficiently and has the role as a regional gateway. This role spans the distribution of import cargo to local markets, but also logistics services for exporters after collecting cargo and providing value adding logistics services in supply chains as a strategic logistics hub (Kim Si-Hyun, Dinwoodie and Kang Dal-Won, 2016). In this paper, a RLDC is defined as a regionally strategic distribution center covering Northeast Asia for global supply chain management.

2.2. Determinants for Locating a Regional Logistics Distribution Center

To offer some insights into factors that might determine the selection of locations for RLDCs, prior studies have focused principally on distribution centers (e.g., Oum Tae-Hoon and Park Jong-Hun, 2004; Nozick and Turnquist, 2001), manufacturing (e.g., Chu, 2002;

Demirel et al., 2010; Sheu, 2003), and facilities (Harris et al., 2014; Kiya and Davoudpour, 2013). In terms of analyzing the determinants of location selection, AHP modelling has been widely adopted and location selection studies have often been conceived as multi-criteria decision making problems (e.g. Bian and Yu, 2006; Pirdashti et al., 2008; Roh Sae-Yeon, Jang Hyun-Mi and Han Chul-Hwan, 2013). More recently the use of Fuzzy AHP and Analytic Network Process models have been preferred to over the AHP model.

Multi-criteria decision making processes assist the strategic agenda for selecting locations because they identify the relative importance of determinants (Demirel et al., 2010). Moreover, they can be used as a tool to select locations and evaluate competitiveness. For example, prior studies on port selection and port competitiveness have adopted the AHP and considered their implications based on the differences between the target ports (Choudhary and Shankar, 2012; Lee Sang-Yoon, Tongzon and Chang Young-Tae, 2013; Lirn et al., 2004; Roh Sae-Yeon, Jang Hyun-Mi and Han Chul-Hwan, 2013). Typically, prior studies that have deployed AHP have adopted a qualitative approach to obtain quantitative results from qualitative evaluations, based on perceived judgments. Although perception-based subjective judgments are usually significantly correlated with objective outcomes, it is preferable to consider both subjective and objective measures when possible. Accordingly, this paper adopted a mixed approach that combines both qualitative and quantitative elements by comparing subjective and objective measures. Table 1 presents factors that have been identified previously which might determine the selection of location for an RLDC. For example, to evaluate the candidate locations for a distribution center, Guo and Zhao (2012) selected seven component factors. Earlier, Oum Tae-Hoon and Park Jong-Hun (2004) adopted 16 criteria to select a location for a multinational corporation's distribution center serving Korea, China and Japan. In a study on location selection for a production/distribution center of a bottling machinery firm, Alberto (2000) employed 7 factors underpinning 25 components. In addition, as demonstrated by Roh Sae-Yeon, Jang Hyun-Mi and Han Chul-Hwan (2013), components for RLDC location may vary according to business environment, which changes as regions and business objectives differ. Recently, Kim Si-Hyun (2017) analyzed the distribution center selection factors in Busan new port hinterland as a multi-functional logistics center. Based on data collected from all 122 samples located in Busan new port hinterland, the identified determinants for location competitiveness were identified as political support, market potentiality, infrastructure utilization, market niche, and connectivity.

Table 1. Components of Regional Logistics Distribution Center Location

Components identified	Source
Effective land Transport system and Logistics costs, Labor costs in distribution Center, Low rental fee for land, Low traffic congestion, Incentive programs offered by host country, Free trade system and related law, Simplicity and ease of administrative procedures, Political stability, Port, airport and intermodal transport facilities, Market size and growth (potential), Availability of trained technical labors, Availability of English speaking port workers, Quality and reliability of modes of transportation, Level of information service, Quality of workers, Quality of life (ex. Public facilities), Accessibility to the relevant business infrastructure, Distance between port and hinterlands, Distance between port and industrial complex, Establishment of feeder service (hub and spoke)	Kim Si-Hyun (2017)
Service, Labor conditions, Logistics costs, Traffic conditions, State of public facilities, Hydrological and geological conditions, Terrain conditions	Guo and Zhao (2012)

Table 1. (Continued)

Components identified	Source
Geo-location, transport linkage and market accessibility, Market size and growth potential of catchment region, Port, airport and inter-modal transport facilities, Labor and other input costs, Skilled labor force, labor quality and labor peace, Flexible immigration, Land and availability and price, Corporate tax incentives, Availability of Free Trade Zone, Info-communications tech/e-business infrastructure, Modern logistics service providers and costs, Competitive financial service sector, Personal income taxes for foreign employees, Pro-business government and officials, Housing, schools, quality of life, environment amenity, Political stability	Demirel et al. (2010)
Labor costs, Transportation costs, Tax incentives and tax structures, Financial incentives, Handling costs, Skilled labor, Availability of labor force, Existence of modes of transportation, Quality and reliability of modes of transportation, Telecommunication systems, Proximity to customers, Proximity to suppliers or producer, Lead times and responsiveness, Policies of government, Industrial regulations laws, Zoning and construction plan	Oum Tae-Hoon and Park Jong-Hun (2004)
Adequacy of port facilities, Spaciousness of port area, Availability of feeder vessels, Availability of land, Affordability of land prices, Low rental fees for land, Availability of English speaking port workers, Availability of specialized technicians, Availability of trained or nor-trained technical labor, Labor costs in distribution center, Level of port information service, Supply of information infrastructure, Distance between port and hinterlands, Distance between port and major cities, Ease of access to parts and raw materials, Distance between port and industrial complex, Existence of large consumer city behind port areas, Quality of workers in distribution center, Incentive programs offered by host country, Simplicity & ease and efficiency of administrative procedures needed in operating distribution centers, Financial assistance in constructing distribution centers, Free trade system and related law provided by the host countries, Airport access to provide speedy linkage between the distribution, center and major markets, Effective land transport system, Establishment of feeder service (hub and spoke system)	ESCAP (2002)
Environmental regulations, Proximity to disposal plant, Taxation, Operating, Start-up, Climate, Crime rate, Traffic congestion, Living expense, Tax incentives, Union, Laws, Skilled labor, Proximity to carriers, Proximity to suppliers, Proximity to customers, Waterway, Rail, Highway, Company's complementary facilities, Facilitation of post-sale service	Alberto (2000)

3. Methodology

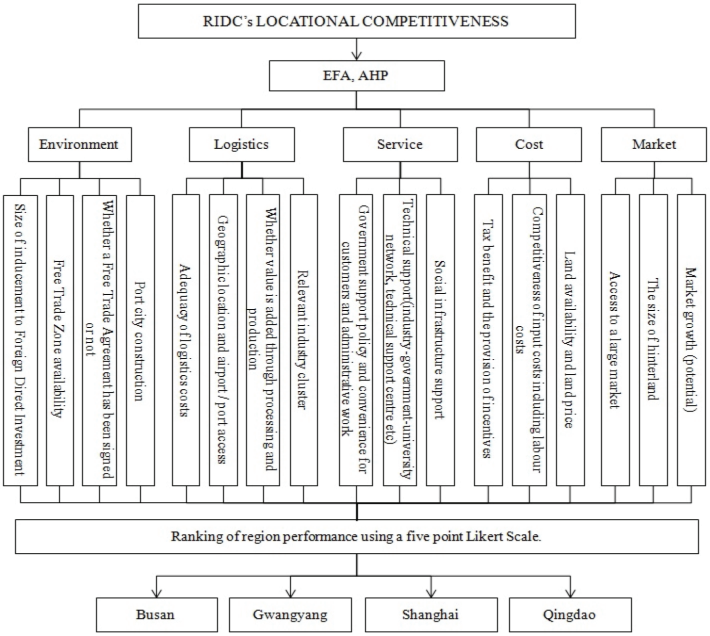
3.1. Research Design and Data Collection

Based on prior research dealing with preferences for international logistics distribution centers in Northeast Asia (Kang Dal-Won and Kim Si-Hyun, 2015), the port-cities located in China and South Korea that were selected comprised of Busan, Gwangyang, Shanghai and Qingdao. Four candidate locations in Northeast Asia were evaluated to extract the determinants of selecting a location for an RLDC. This study adopted factor analysis, and empirical evaluation of the regional performance of target port-cities based on the importance ratio obtained from an AHP analysis. Fig. 1 presents the research model combining the preliminary analysis of the determinants of selecting a location for an RLDC with the evaluation of locational competitiveness among the target port-cities in Northeast Asia.

Prior to collecting data to extract factors that influence the selection of an RLDC in Northeast Asia, overlapping and interrelated items were identified and removed following the preliminary interviews with thirty experts who have extensive knowledge of multi-functional logistics center operations. These included practical and institutional groups such as the board of directors, operational managers, and researchers. After pilot tests, this study distributed 120 structured interviews to port stakeholders in Northeast Asia in early 2018 and collected them all.

To identify the sub-dimensions of competitiveness and eliminate potentially superfluous items, this study adopted an exploratory factor analysis (EFA) using SPSS 22. Based on the results of the EFA, a questionnaire was developed and updated, which comprised of five critical factors underpinning 24 measurement items. The relative importance of measurement items was assessed using a seven-point Likert scale ranging from 1 signifying "equal importance" to 7 representing "very important". The results guided further analysis. Finally, to evaluate the regional performance of potential RLDCs in the target port-cities, location selection factors were assessed using a five-point Likert scale ranging from 1 = "poor" to 5 = "excellent". A questionnaire survey was created and targeted experts incorporating both practical and institutional groups and a total of 420 questionnaires were distributed through multiple methods including interviews, emails and faxes to China (200) and South Korea (200). The effective response rate of 26% (104/400), excluded seven responses that exhibited low consistency (<0.2). In addition, to compare the differences between qualitative and quantitative outcomes, this study also implemented a quantitative evaluation, using the data extracted from prior studies and statistical sources.

Fig. 1. Research Model to Evaluate RIDC's Locational Competitiveness



3.2. Analytic Hierarchy Process

Multi-criteria techniques are considered to offer a promising framework for evaluating decision-making factors since they have the potential to explicitly consider the conflicting, multidimensional, incommensurable and uncertain effects of decision making (Saaty, 1980/ 1990). To analyze the hierarchal structure of determinants for selecting a location of an RLDC, this paper employed an AHP as introduced by Saaty (1980). AHP is a multi-criteria decision-making method that is widely adopted in prior work and can incorporate both tangible and intangible criteria.

The following notation is used in the derivation of the model

Glossary:

A_{ij} $(i=1\ldots N, j=1\ldots N)$	Matrix of comparative values
N	Number of comparative elements
S_j	Column sum of comparative values
V_{ij}	Weighted comparative values
P_i	Priority index of element i
CR	Consistency ratio
B $(i=1\ldots N)$	Matrix of weighted values
λ_{max}	Principal eigenvalue
CI	Consistency index
RI	Random consistency index
X_{ij} $(i=1\ldots N, j=1\ldots N)$	Evaluation factor matrix
p	Significance level.

The AHP technique compares the relative weight of each pair of elements. Therefore, in the numerical assessment of each pair of elements of i and j, the comparative values of the relative weight form a square matrix. Therefore, after defining A and N, the comparative values of the relative weight of each element are calculated in the AHP technique through a synthetization process.

In this process, when a group of elements is evaluated in each decision-making process, the mean values of A_{ij} (that is, the comparative values of the weights j and i) can be utilized for the values allocated for the groups. In a matrix A of the values allocated, the sum of j (column) can be calculated from the following equation.

$$S_j = \sum_{i=1}^{n} a_{ij} \tag{1}$$

The technique associated with AHP which compares multi-criteria in decision-making processes requires various assumptions. It assumes pairwise comparison, evaluation within the relative weights on the identified criteria, independence between criteria, and an assumption that the hierarchal structure incorporates all criteria for decision-making. Therefore, prior work has stressed the importance of four critical principles in the AHP technique: reciprocal comparison ($a_{ij} = 1/a_{ij}$, all $i, j \in$ A), homogeneity ($a_{ij} \neq \infty$, all $i, j \in A$), independence ($a_{ij} = a_i \bullet a_j$, all $i, j \in$ A) and expectation ($\sum a_{ij} = 1$, all $i, j \in A$).

In a matrix A, the weighted values (that is, V_{ij}) can be obtained by dividing the comparative values of the weight of each element (A_{ij}) by the sum of column (S_j). The equation is:

$$V_{ij} = \frac{a_{ij}}{s_i} \tag{2}$$

To obtain the priority index of each element, it is required to calculate the mean values of the normalized weight of each row. When it is defined that Pi is a priority index of the element (i), the equation can be expressed as follows:

$$P_i = \sum_{i=1}^{n} \frac{V_{ij}}{n} \tag{3}$$

Then again, in order to evaluate the consistency of response, a consistency ratio (CR) has to be calculated. Prior to evaluating CR, the weighted matrix can be obtained by a new matrix (n*1) produced by the sum of the values formed when multiplying each column by priority index (Pi). Therefore, the new matrix (B) is referred to as the matrix of the weighted values as follows:

$$B = \begin{matrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{matrix} = \begin{matrix} p_1 a_{11} & p_2 a_{12} & \cdots & p_n a_{1n} \\ p_1 a_{21} & p_2 a_{22} & \cdots & p_n a_{2n} \\ \vdots & \vdots & & \vdots \\ p_1 a_{n1} & p_2 a_{n2} & \cdots & p_n a_{nn} \end{matrix} \tag{4}$$

Based on the results above, the consistency index (CI) can be obtained from dividing the number of elements minus 1 (that is, *n*-1) into the principal eigenvalue (λ_{max}) minus the number of elements in the weighted matrix, as follows:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n-1} \tag{5}$$

Lastly, the consistency ratio (CR) can be obtained by dividing CI into RI (that is, CR = CI/RI). The random consistency index (RI) is the value of a mathematical function against the number of elements to be compared. Table 2 presents the values of RI. For example, when the number of elements (*n*) is 3, the value of a function against the number of elements (RI) is 0.58, or when *n* is 5, the value of RI can be computed as 1.12.

Table 2. Random Consistency Index Values for Different Matrices

n	1	2	3	4	5	6	7	8	9	10
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Consequently, when the values of CR are below 0.1, they are acceptable. However, CR values that exceed 0.2 indicate a lack of consistency although less than 0.2 is considered acceptable. Therefore, it is proposed that when a pairwise comparison is consistent, and $\lambda_{max} = N$ that the results in CI = 0. On the other hand, when the response is not consistent in pairwise comparison, λ_{max} exceeds N (that is, $\lambda_{max} > N$).

As discussed above, the AHP technique offers the advantage of evaluating consistency in pairwise comparisons. This is one of the reasons for employing the AHP technique in multi-criteria decision making problems (Keeney and Raiffa, 1993).

4. Data analysis and Results

4.1. Determinants for the Location of a Regional Logistics Distribution Centre

Before extracting the factors which determine the location of an RLDC in Northeast Asia, sets of determining factors identified in previous studies were refined following interviews with experts. Experts identified any factors that might be redundant or missing and any issues relating to factor validity. After three rounds of testing and modifications, 24 factors were selected that may determine the location of an RLDC in Northeast Asia, as shown in Table 3.

Table 3. Factors Determining Regional Logistics Distribution Center Location

Code	Component determining the location
Item 1	Land availability and land price
Item 2	Tax benefit and the provision of incentives
Item 3	The size of hinterland
Item 4	Export and import competitiveness due to demand creation effect
Item 5	Government support policy and convenience for customers and administrative work
Item 6	Size of inducement to Foreign Direct Investment
Item 7	IT and e-biz industrial infrastructure facilities
Item 8	Social infrastructure support
Item 9	Competitiveness of input costs including labor
Item 10	Access to a large market
Item 11	Market growth (potential)
Item 12	The level of safety of currency and advantage of that currency
Item 13	Geographic location and airport/port access
Item 14	The logistical characteristics of products
Item 15	Adequacy of logistics costs
Item 16	Whether value is added through processing and production
Item 17	Technical support (industry-government-university network, technical support etc.)
Item 18	Relevant industry cluster
Item 19	Port city construction
Item 20	Has a Free Trade Agreement been signed?
Item 21	Whether industry cluster is constructed or not
Item 22	Free Trade Zone availability
Item 23	Quality of labor and ability to speak English
Item 24	The provision of comfortable environments for employees

To identify the sub-dimensions of port competitiveness and eliminate potentially superfluous items the study adopted exploratory factor analysis (EFA) using SPSS 22. Thirteen responses were excluded due to missing data resulting in 120 valid responses. In terms of respondents' profiles, logistics companies, institutions, universities and government institutions accounted for 63.1%, 17.1%, 14.4% and 5.4% of the sample, respectively.

Deploying a principal component analysis with Varimax rotation, the initial 24 items were reduced to 17, and five factors were extracted. Table 4 presents the results of exploratory factor analysis. The results show that all 17 item factor loadings exceeded 0.5, implying that all are statistically significant (Gerbing and Anderson, 1988; Hair et al., 1998). Five latent variables accounted for 75.714% of the total variance based on the 17 observed variables with eigenvalues exceeding 1.0. The measure of sampling adequacy (Kaizer-Meyer-Olkin, KMO = 0.675) and significance for Bartlett's Test (p = 0.000) indicate that the exploratory factor analysis is deemed to be adequate. The internal consistency measured by Cronbach's Alpha was acceptable, exceeding 0.7 (Hair et al., 1998).

Table 4. Results of Exploratory Factor Analysis

Items	Components					Cronbach's Alpha
	Environment	Logistics	Services	Cost	Market	
Item 6	0.775					0.836
Item 22	0.757					
Item 20	0.695					
Item 19	0.675					
Item 15		0.863				0.840
Item 13		0.770				
Item 16		0.726				
Item 18		0.697				
Item 5			0.872			0.793
Item 17			0.796			
Item 8			0.627			
Item 2				0.851		0.769
Item 9				0.741		
Item 1				0.730		
Item 10					0.913	0.733
Item 3					0.775	
Item 11					0.601	
Eig.	2.935	2.893	2.496	2.346	2.202	
Cum.	17.262	34.278	48.961	62.761	75.714	

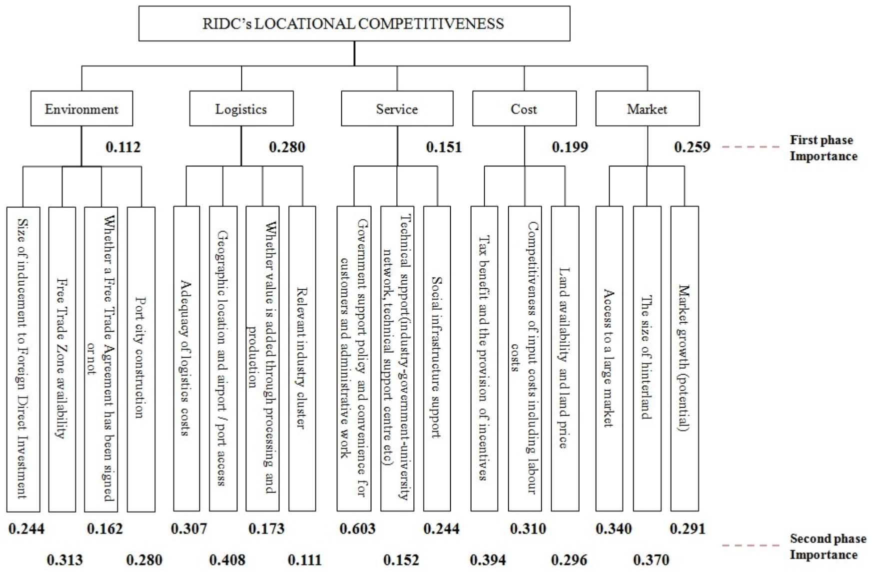
4.2. The Importance Ratio among Location Selection Factors

To obtain the importance ratio among location selection factors, the AHP technique was employed. Table 5 presents the results of the AHP indicating the importance ratios between the main factors. According to the results, the consistency ratio (CR) indicates acceptable ranges indicating less than 0.1 (Keeney and Raiffa, 1993). A logistics factor showed the highest importance ratio, followed by factors relating to the market, costs, services and an environmental factor.

Table 5. The Importance Ratio among Location Selection Factors

	Logistics	Market	Cost	Services	Environment	Importance
Logistics	1.000	1.099	1.329	2.038	2.377	0.280
Market	0.910	1.000	1.308	1.646	2.435	0.259
Cost	0.752	0.764	1.000	1.457	1.539	0.199
Services	0.491	0.607	0.686	1.000	1.558	0.151
Environment	0.421	0.411	0.650	0.642	1.000	0.112
λ_{max}: 5.014, CI: 0.004, CR: 0.003						

Fig. 2 The Importance Ratio of Location Selection Factors (Expanded)



4.3. Evaluation of Qualitative and Quantitative Competitiveness

This study aims to evaluate the competitiveness of locations as an RLDC in Northeast Asia, both qualitatively and quantitatively. At first, in a questionnaire survey taken to collect data, the study qualitatively evaluated locational competitiveness. Table 6 presents the results of the qualitative evaluation of each factor. Considering the importance ratio obtained from the AHP analysis, Shanghai was rated the highest on all factors except service, where Busan prevailed. Busan recorded the second highest values on all other factors. Among the target port-cities, Gwangyang showed the lowest values on all factors because of the low container traffic volume and the low level of port hinterland utilization.

Table 6. The Results of Qualitative Evaluation

	Busan	Gwangyang	Shanghai	Qingdao
Logistics	3.990	2.846	4.212	3.500
Market	3.606	2.606	4.413	3.712
Cost	3.798	3.212	3.981	3.712
Service	3.942	3.231	3.817	3.337
Environment	3.740	2.865	3.971	3.337

Data extracted from prior studies and statistical sources was put into a quantitative evaluation of competitiveness (Table 7). To compare differences between qualitative and quantitative outcomes, items were scored using a five-point Likert scale ranging from 1 = "poor" to 5 = "excellent". The standardized values are calculated by considering the following relationship: when the evaluation factor x_i is positively related to competitiveness, $X_{ij} =$

$\frac{x_{ij}}{max(x_{ij})}$; when there is a negative relationship between the evaluation factor and competitiveness, $X_{ij} = \left(\frac{x_{ij}}{max(x_{ij})}\right)^{-1}$. The same measurement items used for each qualitative evaluation were adopted and analyzed in each quantitative evaluation.

Table 7. Evaluation of Quantitative Factors

	Factors	Content	Unit	Busan	Gwangyang	Shanghai	Qingdao
Logistics	Adequacy of logistics costs	Handing/berthing charge	USD	133	102	170	170
	Geographic location and airport / port access	Distance from hinterland and airport/port	km	23	103	80	50
	Value added processing and production	Number of firms within hinterland	Number	625	118	5,733	600
	Relevant industry cluster	Number of manufacturing firms	Number	27,799	10,536	22,872	5,536
Market	Access to a large market	Distance to main city	km	10	30	30	22
	Size of hinterland	Regional Gross Domestic Product	GUSD	55	9	438	189
	Market growth (potential)	Gross Domestic Product	GUSD	986	986	5,745	5,745
Cost	Tax benefit and provision of incentives	Reduction of tax benefit period and final tax rate	5-point Likert	2	2	3	3
	Input costs including labor	Average wage	USD/ Month	2,807	2,807	412	412
	Land availability and price	Land price of FTZ/Hinterland	USD/m^2	11	8	35	47
Services	Government support policy, customer convenience and administrative work	Degree of deregulation	5-point Likert	3	3	5	5
	Technical support	R&D investment	MUSD	748	65	6,793	1,552
	Social infrastructure support	Road density	km/km^2	1.27	0.84	1.02	0.75
Environ-ment	Inducement to Foreign Direct Investment	Amount of FDI	MUSD	696	463	12,601	3,634
	Free Trade Zone availability	Number of firms within FTZ /area	Ha	0.06	0.01	0.36	0.57
	Free Trade Agreement	Number signed	Number	10	10	10	10
	Port city construction	Future planning area	km^2	35.1	1.59	7.12	6.3

Sources: China Statistical Yearbook (2018), Korea National Statistical Office (2018), Monitor Group and Donga Business Review (2018) and National Bureau of Statistics of the People's Republic of China (2018).

Table 8. Results of Quantitative Evaluation

	Busan	Gwangyang	Shanghai	Qingdao
Logistics	4.000	2.749	3.468	2.738
Market	2.019	1.340	2.872	2.503
Cost	3.071	3.367	4.111	3.815
Services	2.810	2.810	3.566	3.414
Environment	2.771	2.903	2.906	1.894

Table 8 presents the evaluation of quantitative competitiveness, which differs from the qualitative evaluation. The results revealed that Shanghai has the highest values on all factors except logistics, where Busan recorded the highest value. However, Busan scored the lowest value on cost and environment factors. Low labor costs gave Chinese port-cities including Shanghai and Qingdao the highest cost rank among the target port cities, a finding that implies that labor costs significantly influence the cost factor in RLDC operations.

Table 9. Results of Quantitative Evaluation

		Busan		Gwangyang		Shanghai		Qingdao	
		Quan[a]	Qual[b]	Quan	Qual	Quan	Qual	Quan	Qual
Logistics	Com[c]	1.12	1.11	0.76	0.79	0.97	1.17	0.76	0.98
	Rank	1	2	3	4	2	1	4	3
Market	Com.	0.52	0.93	0.34	0.67	0.74	1.14	0.64	0.96
	Rank	3	3	4	4	1	1	2	2
Cost	Com.	0.61	0.75	0.67	0.63	0.81	0.79	0.75	0.73
	Rank	4	2	3	4	1	1	2	3
Services	Com.	0.42	0.59	0.42	0.48	0.53	0.57	0.51	0.50
	Rank	4	1	4	4	1	2	2	3
Environment	Com.	0.31	0.41	0.32	0.32	0.32	0.44	0.21	0.37
	Rank	3	2	1	4	1	1	4	3
Overall	Com.	2.98	3.81	2.53	2.91	3.39	4.13	2.89	3.55
	Rank	2	2	4	4	1	1	3	3

Note: a=quantitative, b=Qualitative, c=Competitiveness.

Based on the qualitative and quantitative evaluations, and the importance ratio obtained from the AHP analysis, the competitiveness of potential RLDCs were evaluated (Table 9). Shanghai was ranked as the most competitive location overall, indicating no significant difference between the qualitative and quantitative evaluations, followed by Busan, Qingdao and Gwangyang, respectively. Some interesting differences in the mean value of factors on qualitative and quantitative evaluations imply a gap between them. For example, the evaluations of Busan differed on cost and service factors, and although rated 4th on both factors in quantitative evaluations, it rated 2nd on cost and 1st in service in the qualitative evaluation. Further, Gwangyang was rated first in quantitative evaluation on the environmental factor, but 4th in the qualitative evaluation. Several statistical evaluations differ substantially from perceived evaluations.

5. Conclusion

In conclusion, this study developed a competitiveness evaluation model for RLDCs, based on a case study of the major port-cities in Northeast Asia. It developed the competitiveness structure of a RLDC, and considered both qualitative and quantitative evaluations to overcome the limitations of earlier studies. The model proposed offers a useful tool for analyzing and overcoming the gap between qualitative and quantitative evaluations. Based on the integrated evaluation model, it is possible to suggest political implications for RLDC development, such as the direction of political support, service differentiation, and infrastructure development. New knowledge is offered for port operators seeking to develop strategies to achieve regional gateway status (Kim Si-Hyun, Dinwoodie and Dal-Won Kang, 2016). Findings that physical and functional aspects of port availability significantly determine locational competitiveness as a regional distribution center imply future strategic development of the port area into a multi-functional business center. According to the results of this study, ports need to secure and improve appropriate physical capacities to be a central point for regional trade: 1) intermediacy and connectivity to the import and export areas, market, and host city; diversification of infrastructure in and around the port area; and 2) centricity based on local cargo volumes and an attractive business environment in and around the port that improves the port's functional availability to invite shipping lines and industry. By not restricting port activities to cargo handling or related services, ports can maintain stable and flexible functions. Services and facilities to improve a port's availability as a central position for industries related to international trade might include a convention center, financial complex or arbitration center (Kang Dal-Won and Kim Si-Hyun, 2017). Superior functional availability as a central point of international shipping and trade can enhance port competitiveness, particularly where the intra-regional trade is high. To improve locational competitiveness as a regional distribution center, strategies for future development must supplement roles as a comprehensive logistics hub with plans to offer an attractive business environment for shipping lines and related industries.

This study also provides practical implications to logistics companies with useful information to guide their strategic decision. The results of the AHP analysis revealed that the logistics factor is the most significant for evaluating the competitiveness of RLDCs. The remaining factors were market, costs, and services environment. In addition, the importance ratio obtained from an AHP analysis was used to reflect the relative importance of the determinants of competitiveness. In the qualitative evaluation, Shanghai was ranked as the most competitive location for an RLDC, followed by Busan, Qingdao, and Gwangyang. Although the evaluation values of competitiveness were different from the quantitative evaluation, the overall ranking was the same as the qualitative evaluation: Shanghai, Busan, Qingdao and Gwangyang. Comparing both evaluation methods, this study reveals that there is a difference between qualitative and quantitative evaluations. For instance, Busan is highly recognized in terms of qualitative assessment, including tax benefits and provision of incentive for developing a port rear complex in Busan New Port, the possibility of support policy and customs administration, and land availability. On the other hand, in terms of quantitative assessment, the results are largely compared to other ports, particularly in the aspect of quantitative factors related to competitiveness of input costs, including wages and technical support. This finding implies that prior work on evaluation models of competitiveness has not successfully measured the gap between quantitative data and experts' evaluations. In order to overcome this limitation, this paper considered both actual data such as actual distance, costs, and the number of companies located as well as expert opinions. Finally, the model proposed in this study can be utilized for evaluating the competitiveness of RLDCs worldwide, suggesting a requirement to consider both qualitative and quantitative alternatives in decision making. In addition, depending on the handled cargo in the RLDC, operational form and logistics characteristics may vary even in location selection. However, the implications discovered in this study analysis pointed out that logistic factors were the most important factor in location selection. Especially, geographical location, and airport/port accessibility must be considered as top priority. One of the main roles of an RLDC is the rapid cargo operation by connecting regions to world and the world to each economic sector. In order to fulfill this benefit, several aspects must be prioritized to gain location competitiveness such as connectivity between ports(sea) and airports(air), locational strategy considering cost sensitivity, service sensitivity of various items, and administrative and financial advantages to reduce the risk of global company investment.

Notwithstanding academic and practical implications, there are some limitations in this study. For example, according to the products handled, the decision making factors for location selection may differ. Therefore, the study suggests than an interesting research direction might be to analyze location selection factors might be through product classification. This will provide more precise and detailed implications for decision-making factors concerning an RLDC.

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