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A Study on Competitiveness Analysis of Ports in Korea and China by Entropy Weight TOPSIS

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ABSTRACT

This study aims to (1) to investigate what are the main factors for evaluation of port competitiveness through an analysis of previous literature review; (2) to compare port competitiveness among a sample of ports in Korea and China using TOPSIS; (3) to determine ways to improve port competitiveness in Korea and particularly for Busan port. After selecting the related criteria on port competitiveness for the analysis, the main relevant criteria are divided into three major categories: port throughput, physical and financial criteria in Korean and Chinese ports. The empirical results indicate that Shanghai, Shenzhen and Busan port are the first three competitive ports. Shanghai port ranked near the top port in this analysis, it ranked fist port in port throughput and port financial category (ranked third port in port physical category), Shenzhen port ranked second port in port physical and port financial category (ranked third port in port throughput category), Busan port ranked first port in port physical category, and Ningbo port ranked third port in port throughput and port financial category in this analysis. The finding to the study suggests that the port competitiveness ranking is similar to the current throughput ranking to the main container ports taken into account in the sample.

1. Introduction

Ports are not only fundamental transport links in supply chain networks, but also important link for the development of national economy and for changing the structure of world shipping; therefore, evaluating the competitiveness of ports has become an important issue related to the survival and development of the port itself[1]. Hence, ports of each country have been recognized as an important factor for the national industrial development and national economic vitality. And ports have a particular relationship with country's industries and it provided the basis of development. However, due to the challenges of a globalized economy, the environment of ports is rapidly changing: Shipping companies exploit economies of scale by deploying mega container ship. But, on the other hand, they decrease the number of calling ports in order to further

[1] Tongzon(2001)

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rationalize overall costs.

In the past, the port competitiveness meant more choices for the end users as an advantage factors or gravity. However, more recently, port competitiveness has a more comprehensive meaning, including dominant factors or gravity for various needs like the demand of terminals' use as a multi-dimensional function[2].

In this changing port environment, the Korean government is marketing the hub port in Northeast Asia strategy with a focus on Busan port; however, there are a lot of difficulties in promoting it because of the rapid growth of Chinese ports. In this context, it sought the strategy alternatives for continuous port competitiveness improvement in a rapidly changing shipping environment in Northeast Asia. For these reason, the paper aims at: firstly, investigate the main factors for evaluation of port competitiveness through previous literature review, secondly, to compare port competitiveness among ports in Korea and China using a TOPSIS methodology and, finally, determine ways to improve port competitiveness in Korea especially for the Busan port.

2. Literature Review

Port competitiveness has been defined by academics in several ways. Port competitiveness has led to competition between ports and it has a competitive advantage. In other words, it shows a criterion to ship owners and shippers for selecting port through various functions for competitive advantage. Therefore, it can be utilized as an indicator that preparing a countermeasure because it identify the opportunities and threats of port.

Song and Yeo (2004) argued that the main factors influencing competitiveness of ports are port throughput, port facilities, geopolitical location of port and the service level of port by AHP. Yap et al. (2006) analyzed port relationship of 5 ports in East Asia (Hong Kong, Busan, Kaohsiung, Shanghai and Shenzhen) through main port connectivity's factors.

Saeed (2009) presented the results of an empirical study conducted by distributing questionnaires to shipping agents working for foreign principals in Karachi, Pakistan. In this study, a linear model is developed in which the dependent variable is total stay in port. The independent variables are vessel type, vessel size, total TEUs, vessel frequency and past visits of the shipping line. All the coefficients are significant.

To identify and evaluate the competitiveness of major ports in the region, Yeo et al. (2008) identified the components influencing their competitiveness and presents a structure for evaluating them. Based on the literature related to port selection and competition, a regional survey of shipping companies and owners to reveal that port service, hinterland condition, availability, convenience, logistics cost, regional center and connectivity are the determining factors in container ports in Korea and China.

Tongzon (2009) implied factors on port choice and found via the existing literature, such as high port efficiency, good geographical location, low port charges, adequate infrastructure, wide range of port services, and connectivity to other ports. Among these factors, adequate infrastructure became an important one on the port selection.

Chou (2010) presented first the canonical representation of multiplication operation on three fuzzy numbers, and then this canonical representation was applied to the selection of transhipment container port. Based on the canonical representation, the decision maker of shipping company can determine quickly on the ranking order of all candidate transhipment container ports and select easily the best one among them.

Sayareh and Alizmini (2014) using TOPSIS and AHP found that the working time, stevedoring rate, safety, port entrance, sufficient draft, capacity of port facilities, operating cost, number of berths, ship channelizing, and international policies are critical factors for selecting container seaport in the Persian Gulf.

Other studies attempting to identify and explain the various factors in shippers' port choice using various methodologies include Mangan et al. (2002), Wong et al. (2008), Nir and Lin (2003), Tiwari et al. (2003a, 2003b), Malchow and Kanafani (2001, 2004), Yeo et al. (2004), Tongzon (1995, 2002) and Ugboma et al. (2006). Table 1 provides a literature reviews on port competitiveness.

Table 1
Literature reviews on port competitiveness

	Authors	Research Findings
1	Saeed et al. (2009); Grosso and Monteiro (2008); Song and Yeo et al. (2004); Lirn et al. (2004); Cullinane et al. (2004)	Cargo handling facilities and ability to handle large volume of cargo
2	Tongzon (2002, 2009); Saeed et al. (2009); Grosso and Monteiro (2009);	Availability and capacity of port facilities
3	Saeed et al. (2009); Song and Yeo (2004); Tongzon (1995)	Cranes efficiency and number of them
4	Saeed et al. (2009); Tongzon (2009); Chang et al. (2008)	Number of berths availability
5	Tongzon (1995, 2009); Grosso and Monteiro (2008)	port productivity
6	Tongzon (2009); Tiwari (2003a, 2003b)	Number of routes offered at the port
7	Tongzon (2002, 2009); Saeed et al. (2009); Grosso and Monteiro (2008); Yeo et al. (2008); Malchow and Kanafani (2004); Song and Yeo (2004)	Operation cost (port and cargo/passenger dues, berth charges, victualling, hire of handling equipment, pilotage, towage and passenger and cargo handling costs)
8	Tongzon (1995, 2009); Yeo et al. (2008); Blonigen and Wilson (2008)	The oceanic distance from the port to destination of shipments
9	Tongzon (2009); Grosso and Monteiro (2008); Yeo et al. (2008); Song and Yeo (2004)	Seaport service level
10	Tongzon (2002, 2009); Grosso and Monteiro (2008); Yeo et al. (2008); Blonigen and Wilson (2006); Malchow and Kanafani (2004); Tiwari (2003a, 2003b); Lirn et al. (2004)	Efficient intermodal links to the port (road, rail, air, feeder etc.)

There are many studies about port competitiveness by considering various factors. They utilized several port facilities (i.e. cargo handling facilities, capacity of port facilities, number of cranes and berths etc.), financial (i.e. operation cost etc.) and port throughput (i.e. port productivity) factors. Therefore, this paper intends to expand previous research studies by separating 3 large categories namely port throughput, physical and financial criteria for analyzing container port competitiveness in Korea and China.

3. Methodology

The concept of TOPSIS (Technique for Order Preference by Similarities to Ideal Solution) is a technique for solving multiple criteria decision making problems.

As a method of comprehensive evaluation of distance, the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS), and also have the farthest distance from the Negative Ideal Solution (NIS)[3].

[2] Kim et al.(2008)

[3] Sayareh and Alizmini(2014)

PIS is the solution, which maximizes the benefit criteria and minimizes the cost criteria, on the other hands NIS is the solution that maximizes the cost criteria and minimizes the benefit criteria.

TOPSIS is suitable for cases with a large number of attributes, alternatives and handy for objectives with quantitative data because it alleviates the requirement of paired comparisons and the capacity limitation may not significantly dominate the process[4]. However, because weight attributes are of great importance in TOPSIS. It is necessary to develop weighting algorithm calculation for keeping consistency of judgment of decision making method. Also, it needs to utilize previous mixed algorithm method or developing new algorithm in decision making algorithm.

In this research, for objectivity of the evaluation, it was adopted the entropy weighting method to avoid subjective effects. The TOPSIS solution technique comprises a series of stages as follows[5].

Step 1: Construct the Initial Matrix.

In this step, it is listed in the attributes depending on the type of them by a matrix. Initial matrix X is as follows:

$$X = (x_j)_{m\times n} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \qquad (eq.\ 1)$$

Here, $i = 1, 2, \cdots, m,\ \ j = 1, 2, \cdots, n$

Step 2: Construct the Normalized Matrix.

It transforms various dimensional attributes into non-dimensional attributes, which allows to compare among criteria in this step. Normalized matrix P is as follows:

$$P = (p_j)_{m\times n} = \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ p_{m1} & p_{m2} & \cdots & p_{mn} \end{pmatrix} \qquad (eq.2)$$

Here, $p_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2}$

Step 3: Calculate the Entropy of each Attribute j.

$$e_j = -/\sum_{i=1}^{m} p_{ij} \times \log(p_{ij}) \qquad (eq.3)$$

Step 4: Determine Weight.

The normalized weighted coefficient w_j is as follows:

$$w_j = 1/(e_j)^2 \times \sum_{j=1}^{n} (e_j)^{-2} \qquad (eq.4)$$

Step 5: Construct the Weighted Normalized Matrix.

Because of difference of each evaluation index, it needs to construct the weighted normalized matrix R.

$$R = (R_{ij})_{m\times n} = \begin{pmatrix} w_1p_{11} & w_2p_{12} & \cdots & w_np_{1n} \\ w_1p_{21} & w_2p_{22} & \cdots & w_np_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ w_1p_{m1} & w_2p_{m2} & \cdots & w_np_{mn} \end{pmatrix} \qquad (eq.5)$$

Step 6: Determine the Positive Ideal and Negative Ideal Solutions.

Positive ideal solution:

$$V^+ = \{(max_i\, S_{ij}\ |j \in J_1), (min_i\, S_{ij}\ |j \in J_2)|i = 1, 2, \cdots, m)\} \qquad (eq.6)$$

Negative ideal solution:

$$V^- = \{(min_i\, S_{ij}\ |j \in J_1), (max_i\, S_{ij}\ |j \in J_2)|i = 1, 2, \cdots, m)\} \qquad (eq.7)$$

In both solutions explained above, J_1 and J_2 respectively represent the set of positive and negative attributes.

Step 7: Calculate the Distance Measures (Separation from PIS and NIS) for each Alternative.

The distance from the positive ideal alternative is:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (S_{ij} - V_j^+)^2} \qquad (eq.8)$$

Similarly, the distance from the negative ideal alternative is:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (S_{ij} - V_j^-)^2} \qquad (eq.9)$$

Step 8: Calculate the Relative Closeness to Ideal Solution C_i.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \qquad (eq.10)$$

Here, $i = 1, 2, \cdots, m$

In this step, the option with C_i closer to 1 is chosen.

Step 9: Rank the Preference Order.

In this step, the decision-maker selects the high ranked alternative.

4. Analysis and Findings

After searching and selecting the related criteria on port competitiveness factors, the main criteria are divided into three categories of throughput, physical and financial criteria in Korean (Busan, Gwangyang, and Incheon) and Chinese (Dalian, Guangzhou, Ningbo, Qingdao, Shanghai, Shenzhen, and Tianjin) ports, as followings:[6]

Throughput Criteria: throughput (TEU, 2014), and increase/decrease rate of throughput (%, 2000 to 2014).

Physical Criteria (2012): berth length (m), the number of C/C, the number of berth, total area (m_2), depth (m), and port centralities (degree, closeness, betweenness and eigenvector centrality)[7].

Financial Criteria (2014): total revenue (Dollar), total expense (Dollar), asset (Dollar), capital NI (Net Income, Dollar), increase/decrease rate of

4 Sayareh and Alizmini(2014)

5 Hwang and Yoon(1981); Shih, et al.(2007); Mahdavi, et al.(2008); Asgharpour(2009)

6 Source: Containerasation International Yearbook 2013, homepages of each port, Ministry of Transport of the People's Republic of China Ministry of Oceans and Fisheries of Korea, Chinamoney, DART.

7 Kim A. R. and LU J. (2015)

NI (%), PCM (price cost margin), ROA (return on assets), and ROE (return on equity).

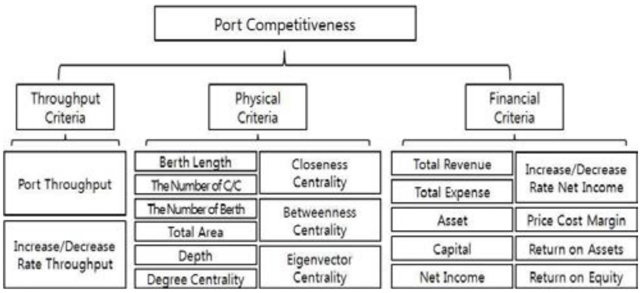

Fig. 1. The main criteria of analysis

4.1 *Analysis on Port Competitiveness by Port Throughput Criteria*

4.1.1 *Construct the normalized matrix*

Based on collected data, it was determined the normalized matrix of port throughput criteria in Korean and Chinese ports by equation (1) and (2).

$$X_1 = \begin{pmatrix} 10{,}128 & 0.140 \\ 16{,}160 & 0.137 \\ 19{,}450 & 0.245 \\ 16{,}624 & 0.158 \\ 35{,}285 & 0.189 \\ 24{,}030 & 0.162 \\ 14{,}050 & 0.179 \\ 18{,}683 & 0.067 \\ 2{,}338 & 0.097 \\ 2{,}335 & 0.100 \end{pmatrix} \quad P_1 = \begin{pmatrix} 0.064 & 0.095 \\ 0.102 & 0.093 \\ 0.122 & 0.166 \\ 0.104 & 0.107 \\ 0.222 & 0.128 \\ 0.151 & 0.110 \\ 0.088 & 0.121 \\ 0.117 & 0.045 \\ 0.015 & 0.065 \\ 0.015 & 0.068 \end{pmatrix}$$

4.1.2 *Calculate the entropy*

In this step, it was calculated the weighted normalized matrix of port throughput criteria in Korean and Chinese ports by equation (3), (4) and (5).

Table 2
The weights of port throughput criteria

		Weight	Max	Min
Throughput Criteria	Throughput	0.531	0.145	0.027
	Increase/Decrease Rate	0.469	0.129	0.061

$$R_1 = \begin{pmatrix} 0.076 & 0.097 \\ 0.101 & 0.096 \\ 0.112 & 0.129 \\ 0.103 & 0.104 \\ 0.145 & 0.114 \\ 0.124 & 0.105 \\ 0.093 & 0.111 \\ 0.109 & 0.061 \\ 0.027 & 0.078 \\ 0.027 & 0.079 \end{pmatrix}$$

4.1.3 *Determine the ideal solutions*

After Calculating the entropy, it was determined that the positive ideal and negative ideal solutions of port throughput criteria in Korean and Chinese ports by equation (6) and (7).

Table 3
Positive ideal and negative ideal solutions of port throughput criteria

		Positive	Negative
Throughput Criteria	Throughput	0.145	0.027
	Increase/Decrease Rate	0.129	0.061

4.1.4 *Calculate the distance measures*

And then, it was calculated that the distance measures of port throughput criteria in Korean and Chinese ports by equation (8) and (9).

Table 4
The distance from the ideal alternatives of port throughput criteria

	Dalian	Guangzhou	Ningbo	Qingdao	Shanghai	Shenzhen	Tianjin	Busan	Gwangyang	Incheon
Positive	0.045	0.035	0.020	0.031	0.016	0.024	0.033	0.049	0.072	0.072
Negative	0.046	0.054	0.071	0.057	0.078	0.066	0.057	0.047	0.027	0.028

4.1.5 *Ranking Port Competitiveness of Port Throughput Criteria*

Finally, it was ranked the port competitiveness in Korean and Chinese ports by equation (10).

The TOPSIS analysis of port throughput has shown that Shanghai, Ningbo, Shenzhen port are the top three ports. It can be seen as the result of China's economic development and port integration policy. In addition, it can be verified that throughput of Chinese small and medium-sized port (SMP, i.e. Dalian, Qingdao, Tianjin) was rapidly growing, and this trend was reflected in competitiveness of port throughput.

On the other hand, competitiveness of Busan port was evaluated lowly because throughput growth of Busan port was slowed down, competitiveness of other Korean ports (Gwangyang and Incheon) was also low. Especially, in case of Incheon port, throughput growth was slower down because competitiveness of near ports (Dalian, Tianjin and Qingdao) has risen. Thus, it can be forecasted that that throughput competitiveness of Incheon port will be weaken increasingly.

Table 5
The ranking port competitiveness of throughput attributes

Rank	Ports	Port Throughput Competitiveness
1	Shanghai	0.827
2	Ningbo	0.783
3	Shenzhen	0.736
4	Qingdao	0.646
5	Tianjin	0.633
6	Guangzhou	0.605
7	Dalian	0.505
8	Busan	0.493
9	Incheon	0.280
10	Gwangyang	0.271

4.2 *Analysis on Port Competitiveness by Port Physical Criteria*

4.2.1 *Construct the normalized matrix*

First, based on collected data, it was determined the normalized matrix of port physical criteria in Korean and Chinese ports by equation (1) and (2).

$$X_2 = \begin{pmatrix} 4{,}253 & 131 & 17 & 2{,}048{,}579 & 15.341 & 37.0 & 0.365 & 1.448 & 14.260 \\ 5{,}370 & 198 & 20 & 4{,}604{,}600 & 12.975 & 34.0 & 0.401 & 2.202 & 19.235 \\ 3{,}748 & 37 & 9 & 757{,}000 & 14.500 & 180.5 & 0.442 & 2.909 & 35.327 \\ 5{,}449 & 160 & 14 & 1{,}322{,}800 & 17.214 & 84.5 & 0.411 & 2.299 & 27.008 \\ 8{,}956 & 485 & 30 & 8{,}569{,}837 & 12.527 & 212.5 & 0.455 & 8.783 & 36.686 \\ 14{,}733 & 281 & 37 & 4{,}160{,}800 & 15.622 & 278.0 & 0.470 & 8.971 & 36.764 \\ 4{,}674 & 128 & 16 & 1{,}859{,}400 & 15.175 & 27.5 & 0.339 & 0.667 & 8.435 \\ 14{,}610 & 334 & 58 & 4{,}277{,}778 & 13.190 & 181.0 & 0.476 & 14.061 & 41.032 \\ 2{,}200 & 75 & 9 & 7{,}797{,}319 & 15.222 & 41.0 & 0.379 & 0.285 & 18.634 \\ 2{,}335 & 25 & 6 & 500{,}000 & 12.250 & 6.0 & 0.316 & 0.014 & 6.383 \end{pmatrix}$$

$$P_2 = \begin{pmatrix} 0.066 & 0.074 & 0.166 & 0.134 & 0.036 & 0.010 & 0.048 & 0.031 & 0.036 \\ 0.063 & 0.066 & 0.048 & 0.042 & 0.044 & -0.332 & 0.074 & 0.132 & 0.141 \\ 0.094 & 0.064 & 0.102 & 0.259 & 0.118 & -0.082 & 0.187 & 0.166 & 0.060 \\ 0.082 & 0.091 & 0.107 & 0.062 & 0.063 & 0.042 & 0.050 & 0.084 & 0.163 \\ 0.342 & 0.296 & 0.246 & 0.257 & 0.620 & -0.119 & 0.128 & 0.363 & 0.320 \\ 0.004 & 0.003 & 0.015 & 0.018 & 0.021 & 0.120 & 0.153 & 0.198 & 0.152 \\ 0.302 & 0.357 & 0.293 & 0.121 & 0.088 & -0.019 & 0.028 & 0.043 & 0.097 \\ 0.042 & 0.046 & 0.020 & 0.083 & 0.009 & 1.205 & 0.056 & 0.067 & 0.015 \\ 0.002 & 0.002 & 0.000 & 0.011 & -0.000 & 0.394 & 0.073 & -0.168 & -0.004 \\ 0.003 & 0.002 & 0.003 & 0.012 & 0.002 & -0.219 & 0.203 & 0.084 & 0.021 \end{pmatrix}$$

4.2.2 *Calculate the entropy*

In the next step, it was calculated the weighted normalized matrix of port physical criteria in Korean and Chinese ports by equation (3), (4) and (5).

Table 6
The weights of physical criteria

		Weight	Max	Min
Physical Criteria	Berth Length	0.106	0.145	0.049
	The Number of C/C	0.114	0.152	0.025
	The Number of Berth	0.108	0.153	0.043
	Total Area	0.115	0.149	0.026
	Depth	0.089	0.110	0.091
	Degree Centrality	0.125	0.152	0.013
	Closeness Centrality	0.089	0.109	0.086
	Betweenness Centrality	0.154	0.159	0.001
	Eigenvector Centrality	0.100	0.130	0.041

$$R_2 = \begin{pmatrix} 0.076 & 0.081 & 0.087 & 0.071 & 0.104 & 0.050 & 0.094 & 0.051 & 0.072 \\ 0.088 & 0.104 & 0.096 & 0.114 & 0.094 & 0.047 & 0.099 & 0.068 & 0.087 \\ 0.071 & 0.034 & 0.058 & 0.035 & 0.100 & 0.130 & 0.105 & 0.081 & 0.122 \\ 0.089 & 0.092 & 0.077 & 0.053 & 0.110 & 0.086 & 0.101 & 0.069 & 0.106 \\ 0.117 & 0.152 & 0.119 & 0.149 & 0.092 & 0.139 & 0.107 & 0.143 & 0.124 \\ 0.145 & 0.124 & 0.131 & 0.108 & 0.105 & 0.152 & 0.109 & 0.144 & 0.124 \\ 0.081 & 0.080 & 0.084 & 0.067 & 0.103 & 0.041 & 0.090 & 0.029 & 0.051 \\ 0.145 & 0.134 & 0.153 & 0.110 & 0.095 & 0.130 & 0.109 & 0.159 & 0.130 \\ 0.049 & 0.056 & 0.058 & 0.144 & 0.103 & 0.054 & 0.096 & 0.015 & 0.085 \\ 0.051 & 0.025 & 0.043 & 0.026 & 0.091 & 0.013 & 0.086 & 0.001 & 0.041 \end{pmatrix}$$

4.2.3 *Determine the ideal solutions*

After second step, it was determined that the positive ideal and negative ideal solutions of port physical criteria in Korean and Chinese ports by equation (6) and (7).

Table 7
Positive ideal and negative ideal solutions of physical criteria

		Positive	Negative
Physical Criteria	Berth Length	0.145	0.049
	The Number of C/C	0.152	0.025
	The Number of Berth	0.153	0.043
	Total Area	0.149	0.026
	Depth	0.110	0.091
	Degree Centrality	0.152	0.013
	Closeness Centrality	0.109	0.086
	Betweenness Centrality	0.159	0.001
	Eigenvector Centrality	0.130	0.041

4.2.4 Calculate the distance measures

Before ranking port competitiveness, it was calculated that the distance measures of port physical criteria in Korean and Chinese ports by equation (8) and (9).

Table 8
The distance from the ideal alternatives of physical criteria

	Dal ian	Guangz hou	Nin gbo	Qing dao	Shan ghai	Shenz hen	Tia njin	Bu san	Gwang yang	Inch eon
Positi ve	0.023	0.019	0.023	0.019	0.008	0.008	0.025	0.008	0.026	0.034
Negat ive	0.01	0.014	0.015	0.013	0.026	0.025	0.010	0.026	0.014	0.009

4.2.5 Ranking port competitiveness of port physical criteria

Finally, it was ranked the port competitiveness in Korean and Chinese ports by equation (10).

The TOPSIS analysis of port physical has shown that Busan is ranked as top one, with Shenzhen, Shanghai and Guangzhou port follow next.

This means that container handling facilities of the world's first ten big container ports (Busan, Shanghai, Shenzhen and Guangzhou port) are well stocked.

Korea government made an effort on improving port physical infrastructure like the construction of Busan new port for attracting transhipment cargo and improving competitiveness. As a result, physical competitiveness of Busan port ranked number one in this study. Thus, it can be verified that the result of the port facility expansion strategy with a focus on Busan port that Korea government pushed.

Table 9
The port competitiveness of physical attributes

Rank	Ports	Port Physical Competitiveness
1	Busan	0.765
2	Shenzhen	0.764
3	Shanghai	0.752
4	Guangzhou	0.424
5	Qingdao	0.408
6	Ningbo	0.394
7	Gwangyang	0.350
8	Dalian	0.311
9	Tianjin	0.280
10	Incheon	0.218

4.3 *Analysis on Port Competitiveness by Port Financial Criteria*

4.3.1 *Construct the normalized matrix*

Based on equation (1) and (2), it was determined the normalized matrix of port financial criteria in Korean and Chinese ports by collected data.

$$X_3 = \begin{pmatrix} 4{,}284 & 2{,}109 & 4{,}284 & 2{,}109 & 94 & -0.225 & 0.508 & 0.022 & 0.044 \\ 990 & 816 & 3{,}518 & 1{,}484 & 158 & 0.172 & 0.175 & 0.045 & 0.106 \\ 2{,}064 & 1{,}425 & 6{,}909 & 4{,}732 & 464 & 0.008 & 0.310 & 0.067 & 0.098 \\ 1{,}045 & 914 & 5{,}841 & 2{,}999 & 160 & -0.152 & 0.125 & 0.027 & 0.848 \\ 14{,}505 & 2{,}808 & 14{,}505 & 8{,}394 & 1{,}041 & 0.288 & 0.806 & 0.072 & 0.124 \\ 46{,}285 & 28{,}140 & 1{,}050{,}147 & 788{,}781 & 18{,}145 & 0.099 & 0.392 & 0.017 & 0.023 \\ 6{,}778 & 6{,}548 & 20{,}521 & 6{,}734 & 277 & 0.072 & 0.034 & 0.014 & 0.041 \\ 596 & 458 & 1.193 & 436 & 68 & 3.346 & 0.232 & 0.057 & 0.155 \\ 23 & 19 & 15 & 51 & -1 & -0.413 & 0.184 & -0.077 & 0.023 \\ 35 & 14 & 161 & 85 & 14 & -0.071 & 0.598 & 0.088 & 0.166 \end{pmatrix}$$

$$P_3 = \begin{pmatrix} 0.056 & 0.049 & 0.004 & 0.003 & 0.005 & -0.072 & 0.151 & 0.065 & 0.028 \\ 0.013 & 0.019 & 0.003 & 0.002 & 0.008 & 0.055 & 0.052 & 0.135 & 0.067 \\ 0.027 & 0.033 & 0.006 & 0.006 & 0.023 & 0.003 & 0.092 & 0.202 & 0.062 \\ 0.014 & 0.022 & 0.005 & 0.004 & 0.008 & -0.049 & 0.037 & 0.082 & 0.536 \\ 0.189 & 0.065 & 0.013 & 0.010 & 0.051 & 0.092 & 0.240 & 0.216 & 0.078 \\ 0.604 & 0.651 & 0.949 & 0.967 & 0.889 & 0.032 & 0.117 & 0.052 & 0.015 \\ 0.088 & 0.151 & 0.019 & 0.008 & 0.014 & 0.023 & 0.010 & 0.041 & 0.026 \\ 0.008 & 0.011 & 0.001 & 0.001 & 0.003 & 1.071 & 0.069 & 0.171 & 0.098 \\ 0.000 & 0.000 & 0.000 & 0.000 & -0.000 & -0.132 & 0.055 & -0.230 & -0.014 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.001 & -0.023 & 0.178 & 0.266 & 0.105 \end{pmatrix}$$

4.3.2 *Calculate the Entropy*

In second step, it was calculated the weighted normalized matrix of port financial criteria in Korean and Chinese ports by equation (3), (4) and (5).

Table 10
The weights of financial criteria

		Weight	Max	Min
Financial Criteria	Total Revenue	0.010	0.137	0.001
	Total Expense	0.011	0.124	0.001
	Asset	0.288	0.032	0.000
	Capital	0.570	0.020	0.000
	NI (Net Income)	0.059	0.066	0.000
	Increase/Decrease Rate of NI	0.047	0.095	0.000
	PCM (Price Cost Margin)	0.004	0.149	0.020
	ROA (Return on Assets)	0.003	0.153	0.000
	ROE (Return on Equity)	0.006	0.145	0.000

$$R_3 = \begin{pmatrix} 0.070 & 0.064 & 0.009 & 0.007 & 0.011 & 0.000 & 0.124 & 0.078 & 0.043 \\ 0.024 & 0.033 & 0.008 & 0.005 & 0.016 & 0.069 & 0.067 & 0.117 & 0.079 \\ 0.042 & 0.049 & 0.014 & 0.013 & 0.037 & 0.007 & 0.095 & 0.140 & 0.075 \\ 0.025 & 0.035 & 0.012 & 0.009 & 0.017 & 0.000 & 0.053 & 0.089 & 0.145 \\ 0.137 & 0.077 & 0.025 & 0.020 & 0.066 & 0.095 & 0.149 & 0.144 & 0.087 \\ 0.132 & 0.121 & 0.000 & 0.000 & 0.046 & 0.048 & 0.109 & 0.067 & 0.027 \\ 0.093 & 0.124 & 0.032 & 0.017 & 0.025 & 0.038 & 0.020 & 0.057 & 0.041 \\ 0.016 & 0.021 & 0.003 & 0.002 & 0.008 & 0.000 & 0.080 & 0.131 & 0.099 \\ 0.001 & 0.001 & 0.000 & 0.000 & 0.000 & 0.000 & 0.069 & 0.000 & 0.000 \\ 0.002 & 0.001 & 0.001 & 0.000 & 0.002 & 0.000 & 0.133 & 0.153 & 0.103 \end{pmatrix}$$

4.3.3 *Determine the ideal solutions*

In third step, it was determined that the positive ideal and negative ideal solutions of port financial criteria in Korean and Chinese ports by equation (6) and (7).

Table 11
Positive ideal and negative ideal solutions of financial criteria

		Positive	Negative
Financial Criteria	Total Revenue	0.137	0.001
	Total Expense	0.124	0.001
	Asset	0.032	0.000
	Capital	0.020	0.000
	NI (Net Income)	0.066	0.000
	Increase/Decrease Rate of NI	0.095	0.000
	PCM (Price Cost Margin)	0.149	0.020
	ROA (Return on Assets)	0.153	0.000
	ROE (Return on Equity)	0.145	0.000

4.3.4 *Calculate the distance measures*

After determining the positive ideal and negative ideal solutions, it was calculated that the distance measures of port financial criteria in Korean and Chinese ports by equation (8) and (9).

Table 12
The distance from the ideal alternatives of financial criteria

	Dalian	Guan gzhou	Ning bo	Qing dao	Shan ghai	Shen zhen	Tianj in	Busan	Gwan gyang	Inche on
Positi ve	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.004	0.004
Negat ive	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.001	0.002

4.3.5 *Ranking port competitiveness of port financialcCriteria*

Finally, it was ranked the port competitiveness in Korean and Chinese ports by equation (10).

The TOPSIS analysis of port financial has shown that Shanghai, Shenzhen and Ningbo port are the first three ports. It has shown the competitive advantage of Chinese ports, due to the high throughput of Chinese ports like Shanghai and Ningbo port.

The results of Korean ports show that there is financial unsoundness. Especially because of Busan new port development and Busan north port redevelopment tariff competition, Busan port has low competitiveness despite high throughput and high physical competitiveness.

Table 13
The port competitiveness of financial attributes

Rank	Ports	Port Financial Competitiveness
1	Shanghai	0.599
2	Shenzhen	0.461
3	Ningbo	0.413
4	Incheon	0.403
5	Tianjin	0.389
6	Guangzhou	0.374
7	Dalian	0.372
8	Qingdao	0.370
9	Busan	0.362
10	Gwangyang	0.148

4.4 *Results of Analysis*

Total competitiveness has shown that Shanghai, Shenzhen and Busan port are the top three ports.Shanghai port ranked near the top port in this analysis, it ranked fist port in port throughput and port financial category (ranked third port in port physical category), Shenzhen port ranked second port in port physical and port financial category (ranked third port in port throughput category), Busan port ranked first port in port physical category, and Ningbo port ranked third port in port throughput and port financial category in this analysis. This result is similar to throughput ranking of recent world's top ten container ports resultingly. As a result it can be shown Chinese ports have competitiveness than Korean ports.

Because of China's economic development and continuous investment, Chinese ports have grown rapidly in throughput, port facilities and financial part. Meanwhile, in Chinese ports, it has port throughput competitiveness of small and medium-sized ports because efforts of Chinese government's port integration policy, but it still needs to improve the competitiveness in port physical and financial part.In case of Korean ports, Gwangyang and Incheon port lower rank in every category. Therefore it is necessary to seek ways to increase port competitiveness in each category (port throughput, port physical, and port financial). Busan port has competitiveness in port physical category, but it also lower rank than Chinese ports in port throughput and port financial category. It seems that the part of existing throughput has shifted to Chinese ports due to remarkable growth of Chinese ports recently. Also, financial competitiveness does not appear noticeably because of a decrease in port profitability for tariff competition of Busan north port redevelopment and the investment of Busan new port.

Lastly determined total competitiveness analyzed in the same way and ranking of each of competitiveness are as shown in Table 14.

Table 14
The results of analysis

Rank	Ports	Total Competitiveness	Throughput Competitiveness	Physical Competitiveness	Financial Competitiveness
1	Shanghai	0.638	0.827	0.752	0.599
2	Shenzhen	0.565	0.736	0.764	0.461
3	Busan	0.495	0.493	0.765	0.362
4	Ningbo	0.424	0.783	0.394	0.413
5	Guangzhou	0.405	0.605	0.424	0.374
6	Qingdao	0.402	0.646	0.408	0.370
7	Dalian	0.359	0.505	0.311	0.372
8	Tianjin	0.359	0.633	0.280	0.389
9	Incheon	0.309	0.280	0.218	0.403
10	Gwangyang	0.288	0.271	0.350	0.148

5. Conclusion

This study aims to (1) to investigate the main factors for evaluation of port competitiveness through previous literature review; (2) to compare port competitiveness among ports in Korea and China using TOPSIS methodology; (3) to determine ways to improve port competitiveness in Korea especially for Busan port.

After selecting the related criteria on port competitiveness factors for analysis, the main criteria are divided into three categories of port throughput, physical and financial criteria in Korean (Busan, Gwangyang, and Incheon) and Chinese (Dalian, Guangzhou, Ningbo, Qingdao, Shanghai, Shenzhen, and Tianjin) ports.

TOPSIS analysis results of port throughput have shown that Shanghai, Ningbo, Shenzhen port are the first three ports. In the physical part analysis, it has shown that Busan port is ranked as first port, with Shenzhen, Shanghai and Guangzhou port ranking next. The financial part analysis has shown that Shanghai, Shenzhen and Ningbo port are the first three ports.

Total competitiveness has shown that Shanghai, Shenzhen and Busan port are the first three ports. Shanghai port ranked near the top port in this analysis, it ranked fist port in port throughput and port financial category (ranked third port in port physical category), Shenzhen port ranked second port in port physical and port financial category (ranked third port in port throughput category), and Busan port ranked first port in port physical category, and Ningbo port ranked third port in port throughput and port financial category in this analysis This result is similar to throughput ranking of recent world's first ten container ports.

To improve port competitiveness, BPA (Busan Port Authority) (1) has pursued a strong market strategy for attracting transhipment cargo from North Chinese ports and port of west coast ports of Japan; (2) has collected and exchanged the international shipping information based on network operating system of Busan port; (3) has improved the logistics environment of Busan port by undergoing dredging operations for deepening Busan new port sea level and eliminating the To-do island etc.

The result of these efforts is reflected in the competitiveness of Busan port. Also, because port strategy is divided into each port now, it is necessary to implement the select and concentration strategy through more detailed analysis. In addition, it needs to establish the different role played by Busan and Gwangyang port and preparing a port integrated system.

In this changing port environment, the Korean government is marketing the hub port in Northeast Asia strategy with a focus on Busan port. However, there are a lot of difficulties in promoting it in this context, sought the strategy alternatives for continuous port competitiveness improvement in a rapidly changing shipping environment in Northeast Asia. For these reason, the paper aimed at: firstly, it investigates the main factors for evaluation of port competitiveness through previous literature review, secondly, to compare port competitiveness among ports in Korea and China using TOPSIS methodology and, finally, determine ways to improve port competitiveness in Korea especially for Busan port.

There may be several ways to further extend the scope of this paper: for example, other factors may be investigated and added into the research like, for example, considering transhipment cargo volume in the port throughput, related port hinterland factors in the port physical and tariff or port dues in the financial analysis. It may be interesting to find out how the competitiveness results of the ports in the sample may change when adding these new factors.

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