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The evaluation of seaport sustainability: The case of South Korea

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ABSTRACT

The concept of port sustainability has gained increasing attention and become one of the most important focus areas for improving port competitiveness. This research aims to identify crucial criteria for assessing sustainability of the ports in South Korea using the importance-performance analysis (IPA) technique. A total of 27 sustainability assessment items encompassing all three pillars of sustainability-environmental, economic, and social aspects-were established from previous research and interviews. A survey was conducted with the port managers to evaluate the importance of the identified assessment measures and their perceived performances. The findings indicate that the economic issue associated with offering employment opportunities was deemed the most important measure, followed by environmental concerns and social factors. They also provide useful managerial insights for the ports to understand port sustainability issues so as to discover areas for improvements and direct their resources to the appropriate areas to enhance port competitiveness.

1. Introduction

There has been phenomenal growth in maritime trade as well as the port industry over the past decades. Seaports, perceived as trade facilitators, play a significant role in the global supply chain and economic system (Lam and Van de Voorde, 2012). Due to serious deterioration of the environment driven by rapid economic growth and pressing global ecological problems, the environmental impact of port operations and development has become an ever-growing issue (Lu et al., 2012). In particular, existence of seaports may create negative environmental impacts on the ocean, soil, and air, resulting in deterioration of both marine and terrestrial ecosystems (Darbra et al., 2009). Thus, environmental issues and impacts related to sustainability have been studied extensively (Denktas-Sakar and Karatas-Cetin, 2012). The social dimension of sustainability, which includes stakeholder management, ethical issues, and corporate social responsibility, has also become increasingly important and has gained growing attention in recent years. However, the social dimension has been relatively ignored and rarely been addressed or studied in previous literature (Shiau and Chuang, 2015).

Lu et al. (2012) stated that as port organisations are the main operators in ports, understanding port sustainability from the port operator's perspective can produce useful information that can be used by governments to develop criteria for promoting sustainable development. Yet, these authors argued that there is near absence of an unambiguous measure for assessing sustainability in the port sector that covers economic, environmental, and social dimensions. Therefore, they established a set of criteria for assessing sustainability of international ports, while considering all three dimensions. Their study was, however, limited to three ports in Taiwan, but this approach can be also applied to identify sustainability criteria in other geographical areas. Besides, a considerable body of prior literature has explored port sustainability in various regions, except South Korea (the UK: Kuznetsov et al., 2015; Spain: Peris-Mora et al., 2005; Taiwan: Lu et al., 2012; Vietnam and Cambodia: Le et al., 2014; Brazil: Roos and Neto, 2017; the EU: Darbra et al., 2009; Puig et al., 2015). South Korea has played a vital role in world trade and shipping. It possessed the seventh largest fleet in terms of deadweight tonnage in 2017; the sixth largest container throughput of roughly 20 million TEU in 2016; the third largest transhipment container throughput in 2016; and major ports such as the Port of Busan, Port of Gwangyang, and Port of Incheon acting as hub ports for Chinese and Japanese ports (United Nations Conference on Trade and Development [UNCTAD], 2017). Despite its important role in world shipping and the need for research on its ports' sustainable development, no studies examined port sustainability in the South Korean context until now. To fill this gap, this study first examines South Korean seaports' sustainability by employing the importance-performance analysis (IPA) technique.

Furthermore, South Korean economy is essentially export propelled, as it developed rapidly through export-led industrialisation strategies

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over the past few decades. Thus, the national and regional economies of South Korea are influenced significantly by port-related industries (Westphal, 1990). Ports in Northeast Asia such as the Port of Shanghai and Port of Hong Kong have been experiencing considerable growth in their overall port traffic, and they are focusing on the sustainable development of maritime operations (Wang and Ducruet, 2012). Establishment of sustainable development strategies has become a most important issue for ports in South Korea in order to achieve competitive advantage and improve their competitiveness. Accordingly, this study aims to apply the approach adopted by Lu et al. (2012) to the ports in South Korea, as there is lack of studies examining the assessment criteria for port sustainability, even though the sustainability concept has become increasingly important for the ports in South Korea. The next section reviews previous studies. Section 3 explains the methodology, while Section 4 shows the analysis and results. Finally, Section 5 presents the concluding remarks.

2. Literature review

2.1. Port sustainability

Port sustainability became important for ports as organisations performed the crucial task of integrating their operational activities with their supply chains and adapted to the business demand and environment, wherein the concept of sustainability is of mounting importance (Denktas-Sakar and Karatas-Cetin, 2012; Lu et al., 2012). The concept of sustainability is increasingly being embraced as a standard business practice, and hence sustainability for ports can be defined as business strategies and activities that meet the current and future needs of the port and its stakeholders, while protecting and sustaining human and natural resources (American Association of Port Authorities, 2007). Based on the triple bottom line (TBL) principle, the concept of port sustainability covers three major aspects (Adams et al., 2009; Sislian et al., 2016): The economic aspect involves returns and profitability of port investments, provision of port facilities that would enhance the performance of companies, and efficiency of the utilisation of port facilities and area. The environmental aspect includes environmental performance and provision of management facilities for air and water quality, dredging operations and disposal, and noise pollution. The social aspect involves direct or indirect contribution to employment in the companies, liveability of areas in the vicinity of ports, and port-city interaction and interrelationships.

Although port activities and developments encourage both economic and commercial growth, they tend to have adverse effects on the environment, with the deterioration of air, water, and soil quality in the vicinity of port areas and noise pollution being the most common issues (Trozzi and Vaccaro, 2000; Ault et al., 2009; Roh et al., 2016). Although port sizes and geographical conditions as well as activity profiles may vary by ports, port authorities are increasingly realising the importance of sustainability and are required to direct their management objectives toward sustainable development while fulfilling economic demands, cost and risk reduction, and port industrial activities (Puig et al., 2015; Roh et al., 2016).

2.2. Port sustainability assessment

The concept of sustainable development and sustainability is clearly the foundation of sustainability assessment (Pope et al., 2004). International organisations including UNCTAD, International Chamber of Shipping, the UN Global Compact, International Maritime Organization, Organisation for Economic Co-operation and Development, and many others have suggested relevant principles stating that assessment for sustainability should incorporate economic, environmental, and social aspects, which are inextricably linked (Lu et al., 2012).

A large number of international ports have presented sustainability reports and developed sustainability assessment criteria about the three components, or pillars, of sustainability (Lu et al., 2012). The Port of Busan, which handled the sixth largest container throughput in the world in 2017 and is the largest container seaport in South Korea, actively initiated a plan for port sustainability and environmental friendliness. Busan Port Authority (BPA) established the 'Comprehensive Plan to Establish Green Busan Port' to address the environmental impacts of port operations in 2012, as green performance, including air, marine, and noise pollution management, is regarded as a key sustainability issue for the port. BPA evaluated sustainability in accordance with the three aspects of the TBL concept, namely, economic, environmental, and social value creation. It also considered other sustainability issues of the port as well, such as improving competitiveness as a global hub port, developing future growth engines, enhancing the port safety management system, increasing customer satisfaction, generating employee value, promoting strategic social contribution activities, and expanding shared growth activities (BPA, 2014). Along with the TBL approach to sustainability, the Port of Los Angeles (2011) introduced the grow-green philosophy to operate in the most environmentally and socially responsible way and pursue long-term growth. The Port of Los Angeles developed the 'Sustainability Assessment and Plan Formulation' to evaluate sustainability efforts and identify material issues that are deemed most significant for achieving sustainable operations. These material issues include health risk reduction, air and water quality, energy and climate change, relationships with stakeholders, habitat protection, open space and urban greening, land use, local economic development, environmental justice, and green growth (Port of Los Angeles, 2011).

Building a green port and adopting green port policies and regulations to accelerate green port strategies have become common practices for enhancing port sustainability effectively (Shiau and Chuang, 2015). This is because green port policies can be used to direct ports to incorporate sustainable practices into their operations and developments by encouraging an organisational culture of environmental improvement and economic and social responsibility (Lam and Notteboom, 2014). Thus, many international ports consider green performance as one of the most important sustainability indicators (Lirn et al., 2013).

Environmental issues in ports have become increasingly important, and they have become a crucial topic in the global trend towards sustainable development. Hence, port environmental issues in the context of sustainability have become a subject of research for many scholars around the world (Shiau and Chuang, 2015). Gupta et al. (2005) investigated the environmental impacts of port and harbour activities and operations and identified sources of pollution. They showed that the impacts are mainly associated with surface water quality and air quality, the former being caused by bilge and sludge wastes, sewage, and oil discharge and leakage generated by ports and the latter being caused by dust and particulate matter from traffic, emissions from transport vehicles and ships, construction activities, rock excavation, and site clearing. Their research also included various measures for the protection of the environment as well as for prevention and control of water and air pollution, which will be useful for developing an appropriate environmental management plan for ports and harbours. Ng and Song (2010) assessed the environmental impacts of daily routine activities and shipping operations in ports, such as cargo stevedoring and bunkering, and they conducted an empirical analysis for the Port of Rotterdam.

Yet, Peris-Mora et al. (2005) indicated that there is very limited research on the main indicators of port sustainability and hence proposed a system of indicators for sustainable management. The research was, however, focused on environmental sustainability rather than economic aspects, and 17 environmental sustainability management indicators were developed. Lirn et al. (2013) also examined green performance criteria in particular and focused on five dimensions, namely, air pollution, noise pollution, solid waste pollution, liquid pollution management, and marine biology preservation, to come up with 17 green performance indicators by using the analytic hierarchy

process. As environmental problems have been the topic of discussion for a long period of time, the majority of literature on sustainability has focused on the environmental aspect rather than the social or economic aspect (Seuring and Müller, 2008), although they are all very important for a comprehensive analysis and assessment of port sustainability (Yap and Lam, 2013). Yap and Lam (2013) stressed the importance of the balance between the three aspects of the sustainability issues in ports and coastal development and addressed not only environmental but also the social and environmental impacts of Asia's port development and growth. The social dimension of sustainability has been regarded as highly associated with stakeholder relationships of ports (Denktas-Sakar and Karatas-Cetin, 2012), and Shiau and Chuang (2015) established an indicator system based on the TBL concept and stakeholder analysis for assessing port sustainability.

Considering the three pillars of sustainability, Roh et al. (2016) identified key management criteria for sustainable port development and further divided their study into internal and external management aspects. Environmental management criteria identified by Roh et al. (2016) include establishing a clear environmental policy, reducing environmental risks and damages, and collaborating with business partners to manage environmental risks and develop a green supply chain. The identified management items related to economic issues include saving costs through the use of cleaner technology, and those related to social issues include improving welfare and working conditions for employees, providing training and education for employees, and supporting community social and community economic activities.

Lu et al. (2012) studied sustainability assessment criteria for ports while considering all three dimensions of sustainability, that is, the environmental, economic, and social aspects. The study was particularly focused on the Keelung, Taichung, and Kaohsiung ports, which are major international ports in Taiwan. With regard to environmental issues, assessment items such as air quality, waste management, noise pollution, water quality, and soil quality were emphasised. In terms of the economic aspect of sustainability, relevant assessment items included employment and local development, economic activity development, port investment, fair competition, and benefits for port operators. Assessment items regarding the social aspect consisted of factors such as security and safety, stakeholder relationships, neighbourhood interaction, port accessibility, and population (Lu et al., 2012). In light of the TBL concept, a total of 27 key criteria for assessing the sustainability of ports were adapted from previous research (Seuring and Müller, 2008; Denktas-Sakar and Karatas-Cetin, 2012; Lu et al., 2012; Lirn et al., 2013; Yap and Lam, 2013; Asgari et al., 2015; Shiau and Chuang, 2015; Kuznetsov et al., 2015; Roh et al., 2016).

3. Methodology

3.1. Importance-performance analysis

The IPA is a simple yet useful technique introduced by Martilla and James (1977). As this technique originated from the marketing discipline, it has become a popular method for examining the strengths and weaknesses of a company or organisation's offering based on consumers' perceived importance and performance. Thus, the IPA method is generally used for prioritising service improvements ever since its introduction (Lai and Cheng, 2003; Feng, 2010). Due to its relative simplicity and ease of application, IPA has been applied to different areas of research, including engineer services and operation strategies (Slack, 1994), banks and financial services (Matzler et al., 2003; Yeo, 2003), hotel services and performance (Weber, 2000), and human resource (Lin et al., 2009).

The IPA method has also been applied to studies on the port sector. Brooks et al. (2010) applied the IPA to their study examining port users' perspective on the effectiveness of a port system. Feng (2010) emphasised that this method of analysis has not yet been used for identifying factors that influence port performance, and thus the author adopted

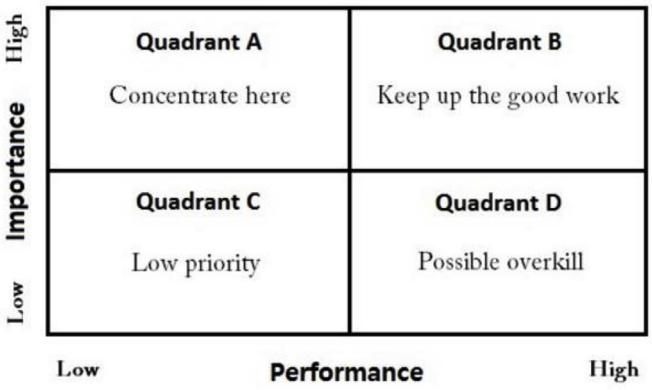

Fig. 1. Importance-performance matrix (Source: Martilla and James, 1977).

IPA to examine port performance, focusing on the logistics capabilities of the ports of Humber and Xiamen and their hinterlands in particular. This study adopts IPA to evaluate sustainability assessment criteria for the ports in South Korea. It is worth mentioning that this particular analysis technique has not yet been applied to the assessment of port sustainability in South Korea. The perceived importance and performance measures of the port sustainability assessment criteria are classified into high and low categories, and a two-dimensional graph, which is composed of two axes representing the mean importance and performance, was constructed. The attributes are then sorted according to their values to be plotted as points on the importance-performance matrix (IPM) for interpretation (Lai and Cheng, 2003; Feng, 2010). The IPM is divided into four quadrants for analysis, as depicted in Fig. 1.

The vertical axis of the IPM represents attribute importance, and the horizontal axis indicates the attributes' perceived performance (Matzler et al., 2004). The four identifiable quadrants of the IPM are labelled and interpreted in the following ways: ‘concentrate here’ in the left upper quadrant A, wherein the attributes are important but not performing very well; ‘keep up the good work’ in the right upper quadrant B, wherein the levels of both perceived importance and performance are relatively high; ‘low priority’ in the left lower quadrant C, wherein the attributes are neither important nor performing very well; and ‘possible overkill’ in the right lower quadrant D, wherein the importance of the attributes is relatively low, but the level of performance is high (Martilla and James, 1977, p. 78).

3.2. Data collection

A self-administered survey questionnaire was designed to measure the sustainability of the ports in South Korea in three aspects: environmental, economic, and social. A five-point Likert-style rating scale was used that includes positive, negative, and neutral statements to measure the importance and performance of the assessment items. The questionnaire was specifically designed to facilitate the use of the IPA technique for data analysis. Therefore, respondents were asked to rank each sustainability assessment item in terms of the level of importance and level of performance (from 1 = very unimportant to 5 = very important and from 1 = performing really badly to 5 = performing really well).

The questionnaires were sent to managers of major container ports, such as the Port of Busan, Port of Gwangyang, Port of Incheon, and Port of Pyeongtaek, to obtain various perspectives around the research area. The abovementioned four seaports are regarded as major container ports handling more than 95% of container throughput in South Korea. The mailing of the questionnaires was followed by a phone call, and a total of 33 questionnaires were received (response rate = 12%). However, three of the responses were found unusable as they were returned incomplete. Therefore, a total of 30 questionnaires contained usable data for the analysis.

4. Analysis and results

4.1. Respondent profile

Results of the respondent profiles from the container ports in South Korea—Port of Busan, Port of Gwangyang, Port of Incheon, and Port of Pyeongtaek—show that great majority of the respondents were assistant managers (58.30%), followed by managers (25%), and senior managers (16.70). Since this research attempts to evaluate the importance as well as performance of the aforementioned sustainability criteria while considering all three dimensions of sustainability in South Korean ports, the views of the port managers might be crucial and deemed more useful than those of chief executive officers or vice chief executive officers. The results indicate that only two respondents have worked in the port industry for less than five years, and most have spent more than five years (ranging from seven to 27 years). Overall, the respondents have spent 8.4 years in their areas, which implies that the data obtained are reliable and valid.

4.2. Data analysis

Table 1 summarises the port managers' perception of the attribute importance and performance of the assessment items.

From the findings, the port managers' perceived importance ratings of the assessment items tend to be high, as the results seem to be all above 3.5 on the five-point Likert scale. These relatively high ratings suggest that port managers attach significant importance to all 27 sustainability assessment measures. Similarly, the attribute performance ratings seem to be relatively high, as the results are recorded between 2.8 and 4.0 on the five-point scale, suggesting that port managers consider that their performance level on the 27 sustainability assessment criteria is high.

The gap, which can be defined as the difference between the mean ratings of performance and importance, is computed and can be found in Table 1. Gap analysis can be considered as a reduction of the two-dimensional analysis of importance and performance shown in Fig. 2 to a single-dimensional scale. The gap analysis is performed by drawing a diagonal line from the lower left side of the matrix to the upper right side where the importance ratings equal the performance ratings,

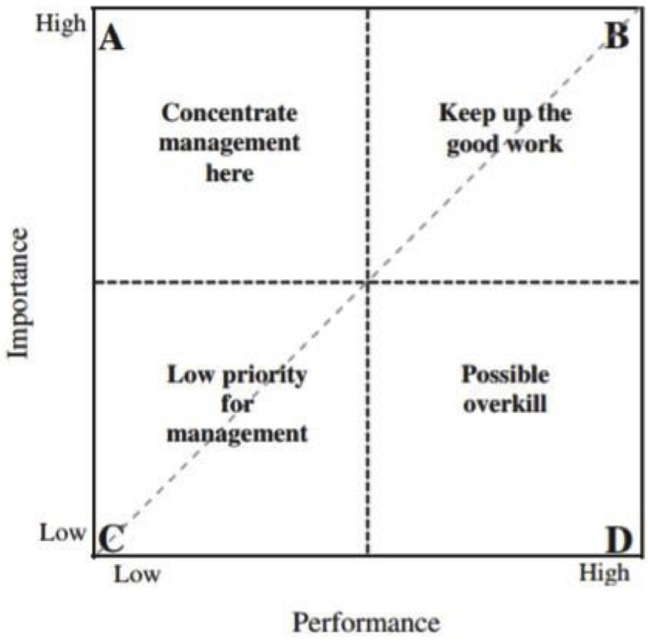

Fig. 2. Importance-performance grid including the diagonal line for gap analysis (Source: Chen, 2014).

Table 1
Means of importance and performance ratings on the sustainability assessment criteria from the port managers' perspective.

Port managers' perspective		Summary of means		
		Importance	performance	Performance minus importance
Environmental				
1	Avoiding use of unpolluted land in port area	4.385	3.385	−1
2	Improving landscape	3.769	3.385	−0.384
3	Avoiding environmental destruction when dredging	4.154	3.462	−0.692
4	Considering environmental protection when handling cargo	4.231	3.462	−0.769
5	Using recyclable or environment-friendly material in port construction	4.154	3.077	−1.077
6	Protecting ecological environment in port area	4.154	3.231	−0.923
7	Reducing noise pollution	3.692	3.385	−0.307
8	Mitigating light influence on neighbouring residents	3.231	2.923	−0.308
9	Preventing disposal of effluents and maintaining water quality	4.308	3.462	−0.846
10	Maintaining air quality	4.077	3.000	−1.077
11	Reducing greenhouse gas emission	3.923	3.231	−0.692
Economic				
12	Facilitating economic growth	4.385	4.000	−0.385
13	Investing in port infrastructure	4.615	3.846	−0.769
14	Establishing port development funding	3.846	2.885	−0.961
15	Attracting foreign investment	3.769	2.962	−0.807
16	Supporting tourism industry development	4.192	3.000	−1.192
17	Offering employment opportunities	4.500	3.385	−1.115
18	Ensuring that cargo is handled safely and effectively	4.462	3.923	−0.539
Social				
19	Recognising requirements of the neighbouring community	4.154	3.692	−0.462
20	Giving support to community social activities	3.538	3.385	−0.153
21	Providing support for employees' training and education	3.846	3.538	−0.308
22	Expanding employees' welfare benefits	4.154	3.231	−0.923
23	Ensuring staff job security	4.462	3.538	−0.924
24	Strengthening port safety management	4.308	3.615	−0.693
25	Ensuring social equality in employment	3.692	3.231	−0.461
26	Consulting interests groups when making port projects	3.538	3.308	−0.230
27	Strengthening port infrastructure for social contribution	4.231	3.462	−0.769

Source: Authors.

thereby allowing the four rectangular quadrants of the IPM to be viewed as two triangular areas (Taplin, 2012; Chen, 2014). Fig. 2 displays the two triangular areas of the IPM divided by the diagonal line for gap analysis.

Attributes located on the right of the diagonal line indicate positive gaps (where the mean performance exceeds mean importance), and those positioned on the left of the line show negative gaps (where the mean performance is lower than the mean importance; Taplin, 2012). As is apparent from the table, the negative gap scores for all 27 sustainability assessment measures indicate that given the perceived importance of the measures, their performance levels are potentially problematic, and thus management attention is required.

A two-dimensional graph in which the perceived performance is plotted on the x-axis and importance is plotted on the y-axis was constructed for each of the three dimensions of sustainability—the environmental, economic, and social aspects. The respective IPMs are presented in the following sections. In accordance with previous studies such as Lai and Cheng (2003), this study adopted the actual mean values of the environmental, economic, and social assessment items to determine the horizontal and vertical lines that create the cross-hair of the IPMs and divide them into four quadrants. Lai and Cheng (2003) used the actual mean values of the measures rather than the midpoint of the five-point scale, which is three, and explained that the reason for this was the applicability to real data. They explained that their obtained data were relatively high values, which means that all the measures would be located in the right upper quadrant B if the scale mean, which is three, was used to divide the matrices into four areas. For a similar reason, this study used the actual mean values of the measures to produce a more useful interpretation and analysis of the findings. In line with previous studies (e.g. Taplin, 2012; Lai and Cheng, 2003), this study did not display scales from 1 to 5 in the matrices (Fig. 3–5), as there were no extreme mean values such as 1 or 5. The horizontal and vertical axis were created based on the cross-hairs (without ranging from 1 to 5), because this way of display may be more effective to show exact mean values (e.g. even decimal points) of importance and performance. The mean values of the importance and performance of the 27 assessment items as perceived by the port managers are divided into three categories, that is, the three aspects of sustainability, and then plotted and positioned in the corresponding quadrants of their respective IPMs. The quadrant location of each plot of the sustainability assessment item on its categorised IPM denotes the appropriate strategy for the attribute. The strategies include concentrate here, keep up the good work, low priority, and possible overkill. The results and findings from the questionnaire are analysed in the IPMs and reported in the following sections.

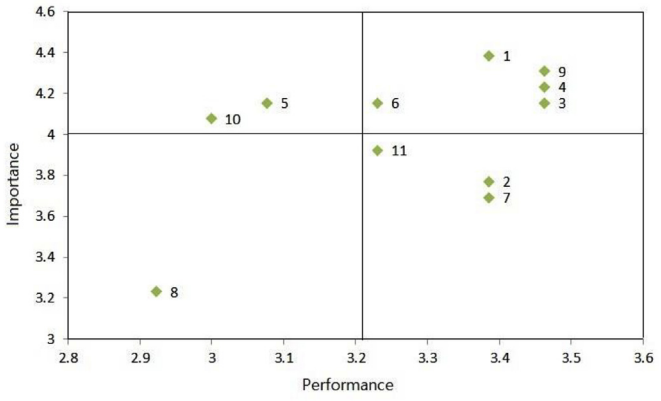

Fig. 3. Importance-performance matrix for environmental criteria from port managers' perspectives.

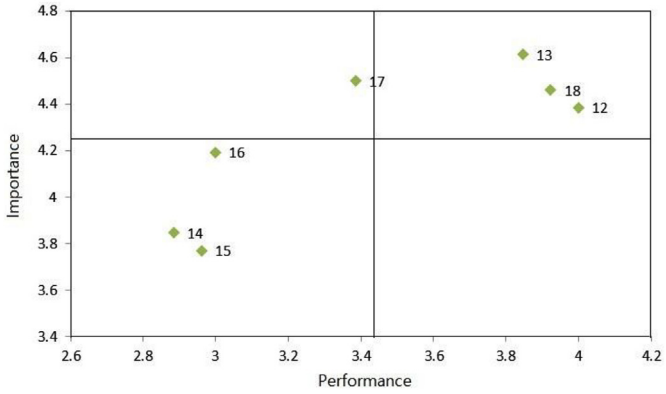

Fig. 4. Importance-performance matrix for economic criteria from port managers' perspectives.

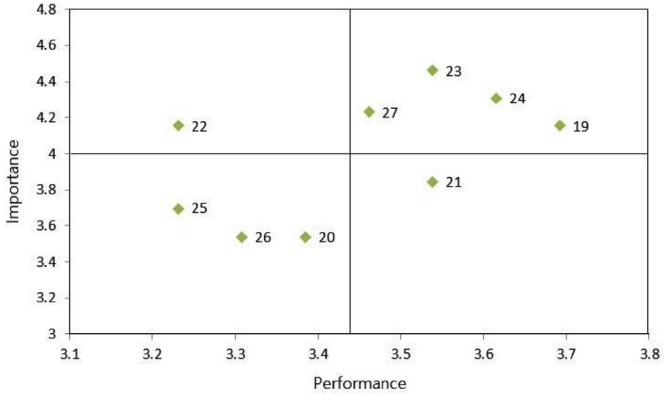

Fig. 5. Importance-performance matrix for social criteria from port managers' perspectives.

4.2.1. Environmental assessment

The port managers regard 'avoiding use of unpolluted land in port area' (mean = 4.385) as the most important criterion for assessing environmental sustainability of the ports in South Korea. This is closely followed by 'preventing disposal of effluents and maintaining water quality' (mean = 4.308), and 'considering environmental protection when handling cargo' (mean = 4.231). The port managers deemed 'mitigating light influence on neighbouring residents' as the least important environmental measure.

4.2.2. Economic assessment

The port managers consider 'investing in port infrastructure' as the most important criterion for port sustainability assessment (mean = 4.615). 'Offering employment opportunities' is perceived as very important as well with a mean importance score of 4.50, but since the mean performance rating of this attribute falls below the average, it is positioned in quadrant A (concentrate here). On the other hand, port managers regarded item 15, which is 'attracting foreign investment', as least significant for assessing sustainability of the ports in South Korea.

4.2.3. Social assessment

The results indicate that amongst the social assessment items, port managers attach greatest importance to 'ensuring staff job security' (mean = 4.462), followed by 'strengthening port safety management' (mean = 4.308) and 'strengthening port infrastructure for social contribution' (mean = 4.231). Meanwhile, 'consulting interest groups when making port projects' is deemed the least important sustainability assessment measure.

5. Results

This research was undertaken with the aim of identifying crucial criteria for assessing the sustainability of ports in South Korea using the IPA technique. IPA analysis helped identify not only measures deemed as the most salient and least important in the context of port sustainability assessment but also how the ports are performing in terms of this range of attributes, thereby drawing management's attention to attributes that attract significant attention or are deemed as having low priority.

It is observed that the mean scores of the perceived importance of all 27 items for assessing the sustainability of Korean container ports are above three on the five-point scale. The findings seem to suggest that port managers attach high importance to pursuing sustainability of the ports in South Korea and consider those 27 items as important for assessing port sustainability. The high importance ratings of the sustainability assessment are expected given the increasing attention on port sustainability issues encompassing all three dimensions—environmental, economic, and social aspects. However, the performance ratings of all 27 assessment measures were less than their corresponding scores of importance, and hence the performance gap, which refers to the mean performance value minus mean importance value, of all 27 measures was negative. The importance-performance gaps found between the extent to which the assessment items are considered important and their perceived level of performance can provide useful insights for further analysis of the assessment of sustainability in Korean ports. It is worth noting that from the port managers' points of view, the largest performance gap score was found for attribute 16, which is 'supporting tourism industry development'. Negative performance gaps indicate that the respondents perceive the assessment items as underperforming and potentially problematic. Moreover, the gaps denote the strengths and weaknesses of the ports in terms of ensuring long-term sustainability, suggesting that more management attention can be directed to areas with large performance gaps, and more resources can be focused on the corresponding factors to improve the ports' sustainability.

It is interesting to note that the assessment items related to economic issues had the highest mean importance rating amongst the three dimensions of sustainability assessment (mean = 4.156), and they were followed by items related to environmental issues (mean = 4.143) and social issues (mean = 4.094). At the same time, they had the highest mean performance rating of all three dimensions, which implies that economic issues are considered the most important aspect of port sustainability assessment criteria, and thus ports focus their resources more on this area than on the other two dimensions. Yet, it should be noted that the negative performance gap reveals that there is a room for improvement so that the performance can be enhanced to achieve long-term sustainability of the ports.

6. Concluding remarks

This study offers a self-evaluation by port service providers of seaport sustainability in the container port industry. This study aimed to identify and evaluate crucial criteria for the assessment of port sustainability, particularly focusing on the ports in South Korea. Previous studies have argued that there are three dimensions or pillars of sustainability—economic, environmental, and social—and these pillars do not conflict with but rather reciprocally support one another. Accordingly, finding the balance between these three aspects is essential for achieving long-term sustainability. Hence, this study also considered all three aspects of sustainability for establishing port sustainability assessment measures, and a total of 27 sustainability assessment measures were identified from previous studies and interviews. Then, this study applied the IPA technique to evaluate the seaport sustainability of four container ports in South Korea. To the best of our knowledge, this is the first study to apply IPA to examine seaport sustainability in South Korea. This study may contribute to the knowledge of port sustainability through an empirical test because, as Laxe et al. (2016) pointed out, there have been only limited contributions to port sustainability with empirical verification, despite great interest in the subject from academic and managerial perspectives.

Overall, the findings indicate that the performance ratings are lower than their corresponding importance ratings. The results and findings show that economic issues with respect to offering employment opportunities are deemed the most important factor for assessing sustainability of Korean ports, followed by preventing disposal of effluents and maintaining water quality, ensuring staff job security, avoiding use of unpolluted land in port area, strengthening port safety management, and so forth. This finding may support Seo and Park (2018)'s argument that ports should contribute to economic growth and employment for their respective regions. Interestingly, the emphasis on economic factors might be reasonable in South Korea, because it is still a developing country that focuses on processing trade, and its citizens might still view economic development as more important than environmental issues. In contrast, this result might be different in developed countries where people have higher income and different perspectives on environmental issues. Moreover, the findings suggest that environmental issues such as preventing disposal of effluents, maintaining water quality, and avoiding use of unpolluted land in port area were salient to maintaining an adequate level of port sustainability, which is in line with previous studies' findings (Peris-Mora et al., 2005; Laxe et al., 2016). From the port managers' perspective, it appears that social aspects such as ensuring staff job security and strengthening port safety management also need to be considered for port sustainability. Notably, such findings imply that the appropriate level of port sustainability can be achieved only when the environmental, economic, and social dimensions intersect, as many sustainability academics have stressed. In other words, deployment of the TBL principle in isolation may not lead to the achievement of port sustainability. The mean importance scores for all 27 attributes were relatively high, which means that the respondents regarded the items as important sustainability assessment criteria. Yet, considerably less importance was attached to the environmental issue related to mitigating light influence on neighbouring residents. In general, assessment measures related to economic issues are considered the most important criteria, followed by the items related to environmental concerns and social issues.

This research contributes to both policy and theoretical knowledge by addressing the need for a balanced approach in seaport sustainability. It fills the research gap by examining the importance of seaports' sustainability factors and current performance factors. This research not only identified a number of crucial criteria for port sustainability assessment but also ranked the assessment items by their perceived importance. The findings would provide useful information to the government, port authorities, port policymakers, and port managers to both determine the areas on which to focus their resources through identification of important sustainability criteria and to develop policies for assessing port sustainability.

There are, however, several limitations in the research findings. The scope of the research is limited to the evaluation of port sustainability assessment criteria, and this study focused on the ports in South Korea in particular. In this research, only four container ports in South Korea were considered: Port of Busan, Port of Gwangyang, Port of Incheon, and Port of Pyeongtaek. Moreover, in terms of collecting data, the respondents were limited to port managers. Future research could overcome the aforementioned limitations by applying this approach to other geographical areas. Furthermore, future research could incorporate a wider range of perspectives, including those of other port stakeholders such as the local community, carriers, and stevedoring companies. In addition, future studies could replicate this research using different methodologies for data collection and data analysis to triangulate the results and findings. Finally, future studies may compare various countries by employing other variables such as the economic level and

citizens' recognition of the seaport, as it is plausible that a more developed country might be more concerned with green issues, whilst a developing country might only focus on economic issues.

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