Port performance in container transport logistics: A multi-stakeholder perspective

Abstract

This study proposes a measurement instrument for port performance in the context of container transport logistics (CTLs) by taking perspectives from different port stakeholders. An importance-performance analysis (IPA) is used to develop an analytical tool for investigating the importance and performance (IP) of major container ports in South Korea against individual CTLs criterion. The main originality of this study is the development of a measurement instrument to provide managerial and operational insights to both port managers (i.e. terminal operating companies) and policy makers (i.e. port authorities and government) for stakeholder management in CTLs. The analysis helps port managers and policy makers to converge the different objectives and concerns for better management.

Keywords: port performance; container transport; stakeholder management; terminal operating companies; importance-performance analysis

1. Introduction

Based on the definition of the transport logistics industry defined by Lai and Cheng (2003), container transport logistics (CTLs) can be defined as the relevant activities of helping the physical movements of a container box from a point of origin via container ports to a point of destination in a CTLs chain. Since the first containerized transportation in the 1950s, more than 60 percent of the world's general cargo is being carried by containers and the total amount shipped between highly industrialised countries approaches more than 90 percent (World Bank, 2007). In this CTLs system, diverse firms essentially collaborate with each other in creating and sustaining values together within the same value-driven chain. In this respect, container ports have become the backbone in defining the efficiency of CTLs systems in global logistics and supply chains (Ng and Liu, 2014; Yang and Chen, 2016). However, port and its hinterland bottlenecks in the CTLs have been continuously concerned by academia and practitioners (Brooks and Schellinck, 2013). This is because ports are complex systems where various individuals and interests coexist, which make port managers have difficulty in making decisions for resource allocation in the management of ports (Notteboom and Winkelmans, 2003; Brooks and Schellinck, 2013). To this end, use of stakeholder management principles is in a high demand in the port and transport logistics domains and they have been profoundly adopted in recent years to reconcile the conflicting interests of different port stakeholders (Lai and Cheng, 2003; Brooks et al., 2011; Lam et al., 2013; Books and Schellinck, 2013; Schellinck and Brooks, 2014; De Martino et al., 2013; Notteboom et al., 2015; Acciaro, 2015). The core of their arguments is that ports have to attach a high level of internal integration within a firm and effective collaboration with the external operation of inter-firms in the supply chain, which in turn leads to overall performance improvement in the whole chain. This motivates a need for research by developing a new approach that can help port managers in diagnosing their ports' status quo, and in strengthening port competitiveness in the context of CTLs. Ultimately, the relevant studies in the literature are still scanty. More evidence on the usefulness of new approaches in this area particularly that obtained from empirical studies is required with high desire from both academic and industrial perspectives (Brooks and Schellinck, 2013; Ha et al., 2017a).

In this regard, this study adopts the stakeholder management principles in assessing port performance within the context of the CTLs, by taking the perspectives from different port stakeholders. Applying the concept in the South Korean port domain, this study shows an interesting illustration since the South Korean port industry is growing its importance, particularly, in a country with an international trade-oriented economy. For instance, the import/export trade value approaches to 95.95% of GDP in South Korea (Statistics Korea, 2014). A container port is denoted by a connection point linking sea and inland transportation, and its users such as shipping companies, freight forwarders and multimodal transport operators are an intermediary in the CTLs chain where their collaborative working practices are crucially demanded to facilitate the physical flows of containers in the international supply chains (Wang et al., 2016). In terms of its geographical scope, this study investigates the ports of Busan New, Busan North, Gwangyang and Incheon in South Korea. The case ports covered 94.5% of total container throughput of South Korea in 2014. They serve more than 500 service routes to the globe (e.g. 523 service routes in 2014), however, their service routes are being duplicated and competed. In this intense port competition and transport chain duplication, TOCs need to establish well-rooted managerial and operational relations with relevant stakeholders. In this respect, we address the research need based on stakeholders' interests-oriented performance measurement, involving all relevant stakeholders in the CTLs to deliver mutual benefits to them within the same value-driven chain. This helps port managers in managing relevant stakeholders to secure continuing relations with salient stakeholders.

The aim of this study is twofold. First, it provides an instrument to measure stakeholders' interests-oriented port performance for stakeholder management. In particular, we attempt to formulate the strategies of stakeholder management from terminal operating companies (TOCs)' perspective in establishing sustainable growth and to satisfy the needs of internal and external stakeholders. Second, an importance-performance analysis (IPA) is used as an analytical tool in this study to investigate the importance and performance of each investigated port against individual criterion (i.e. port performance indicator: PPI). This study presents the two distinctive differences from previous studies in implementing IPA. On the one hand, this study uses an analytic hierarchy process (AHP) to obtain attributes' importance, while on the other hand, we introduce both quantitative and qualitative PPIs to demonstrate the applicability of IPA beyond service satisfaction contexts. There are many advanced approaches in IPA, however their fitness in this research context has not been well addressed in previous studies.

The remainder of the paper is structured as follows. In the next section, the theoretical backgrounds of stakeholder management principles and IPA are reviewed. A new applied methodology for implementing IPA in port performance measurement from a whole chain perspective is outlined in Section 3. In Section 4, an empirical research on the performance of four major Korean container ports is conducted using IPA, with a discussion of the results, the business and academic implications. Section 5 concludes this paper by discussing the study's contributions and recommendations for further research.

2. Literature review

2.1. Port performance measurement as a tool for stakeholder management

It is a challenging task to reconcile the conflicts of internal and external port stakeholders in CTLs because the diverse stakeholders bring different perspectives to the inter-firm collaboration practices (Notteboom and Winkelmans, 2003; Brooks and Schellinck, 2013). To this end, performance measurement has become an important tool in stakeholder management (Brooks et al., 2011; Books and Schellinck, 2013; Schellinck and Brooks, 2014) while at the same time the challenging multi-stakeholder environment complicates port performance measurement (Ha et al., 2017b). For example, measures related to the cost efficiency of container handling operations in the container terminal be of fundamental significance for terminal operators. However, the measures might not be a main concern to shipping lines. Instead, shipping lines might assign greater value to a low service price with a guaranteed service quality level. This indicates that the measures associated to each port stakeholder for overall port performance measurement are intertwined in practice. Consequently, conflicts of interests between port stakeholders require them to interpret others' assertiveness correctly so that ports can deliver a high degree of service excellence of modern ports (Schellinck and Brooks, 2014; Ha et al., 2017b).

Managing relevant stakeholders has been considered as a key strategy in maritime and port domains to strengthen relations with salient stakeholders (Notteboom et al., 2015). Preston and Sapienza (1990) argued that stakeholder management is a key mean of firm's performance to deliver mutual benefits to all related parties via agreeing their diversified interests. According to Freeman (2004), stakeholder management enables port managers to manage the concerns of all stakeholders to develop agreed and supportive objectives and business strategies for long term success of firms. To this respect, stakeholder management in port management can be understood as the attainment of conversing different objectives and conflicting interests among the port stakeholders (De Langen, 2006; Parola and Maugeri, 2013; Notteboom et al., 2015). As a result, an effective stakeholder management of the port domain has been increasingly documented as a main driver in building a competitive advantage for port authorities (PAs) and terminal operating companies (TOCs) (Heaver et al., 2001; Yap and Lam 2004; Haugstetter and Cahoon, 2010; De Martino et al., 2013; Lam et al., 2013; Notteboom et al., 2015). In addition, it is widely acknowledged that stakeholder management practices can be used as a tool for identifying and prioritising port investments to facilitate opportunities for performance improvement, and in sequence to lead to a sustainable future growth (Brooks and Schellinck, 2013). Performance improvement in the CTLs depends on the success of balancing resource allocation to create close relationships with the stakeholders through effective management of combining diverse interests toward an agreed objective (Brooks and Schellinck, 2013). Also, the strategic management of relationships and networking in the value chain enables performance improvement throughout the broader supply chain level (De Martino et al., 2013). However, their attentions to stakeholder management in the port domain have mainly focused on the role of a PA who, as a key driver in the domain, has the responsibility to treat it. Stakeholder management at the level of TOCs remains scanty, indicating more attentions should be made for investigating their roles that are significantly important in the landlord port model. There is a clear recognition that TOCs (or terminal) are a key resource in the PA's concerns to meet needs of port users' (especially shipping lines) (Heaver et al., 2001; Robinson, 2002; Song and Panayides, 2008; Lee and Hu, 2012; Hales et al., 2017). In this regard, this study treats TOCs as a key player in the CTLs system and their performance needs to be measured by taking perspectives from different stakeholders.

2.2.Importance-performance analysis

Port performance measurement (PPM), as a main segment of port and logistics research, has drawn much attention from academia and industry. The early efforts of the theme have particularly focused on the port efficiency issue through the application of the parametric and non-parametric approaches such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA) using quantitative inputs with quantitative outputs (i.e. quantitative PPIs) to evaluate port/terminal efficiency and productivity (see Gonzalez and Trujillo, 2009). These parametric and non-parametric approaches allow to identify the lower or upper boundary of efficiency utility by measuring the productivity distance between alternative ports and the best port (e.g. benchmarking purpose). On the other hand, the study on port effectiveness has focused on measuring service quality (i.e. qualitative service PPIs) in the ports. Compared to port efficiency and productivity studies, research focusing on port effectiveness was lacking until the mid-2000s. They are fortified by the growing number of studies not only using the SERVQUAL methodology (Ugboma et al., 2007; Pantouvakis et al., 2008; Ugboma et al., 2009) but also using the importance-performance analysis (Brooks et al., 2011; Lee and Hu, 2012; Brooks and Schellinck, 2013). Regardless of the port efficiency and effectiveness studies, they separately dealt with either quantitative indicators or qualitative indicators, indicating the fragmented approach is not sufficient to measure and diagnose port performance (Ha et al., 2017a). Ha et al. (2017b) developed a new PPM model that can deal with both efficiency and effectiveness PPIs (i.e. both quantitative and qualitative PPIs) within a single framework. However, the results derived from the synthesis of the PPIs weight (i.e. PPIs importance) with both qualitative and quantitative evaluations of the PPIs (i.e. PPIs performance) provide for the ranking of the case ports in terms of their overall performance with respect to multiple PPIs as well as a PPI's ranking with a single performance value. They failed to provide decision makers with a strategic guidance for performance improving decisions and we see a need for research through comparing analysis between the PPIs importance and performance to visually present both data (i.e. PPIs importance and performance) and strategic suggestions.

Importance-performance analysis (IPA) is a method capable of identifying which attributes of product or service under-performs or over-performs with respect to given their associated importance (Martilla and James, 1977). For the diagnostic or monitoring purposes, the technique makes it possible for decision makers to translate the results into managerial actions for performance improvement. In this regard, IPA has been widely applied for strategy formulation in various areas including tourism (Tonge and Moore, 2007), health services (Abalo et al., 2007), education (Ford et al., 1999), port and logistics (Lai and Cheng, 2003; Lee and Hu, 2012; Brooks and Schellinck, 2013; Schellinck and Brooks, 2013).

Notwithstanding its usefulness in applying empirical settings, IPA is still criticised by many practical issues, in particular, such as grid partitions of importance performance matrix (IPM) and importance measurement. As seen in Fig. 1, different types of IPM have been introduced in previous studies of IPA. Fig. 1 (a) is a general type of IPM introduced by Martilla and James (1977). The cross-hair points can be determined by either means of the scale or actual means of the importance and performance, which is called 'scale (or data)-centred quadrants', respectively (Bacon, 2003). However, determining the cross-hair points is still in controversial, thus needs to be determined in terms of internal (i.e. tangible and intangible resources) and external (i.e. firms market position) environments as Lai and Hitchcock (2015) suggested. There are two axes which constitute four quadrants in which every attribute is positioned in terms of its importance and performance. The attributes shown in the quadrant A: concentrate here, indicate the status of under-performance (i.e. low performance and high importance), while the attributes in the quadrant D: possible overkills, imply the status of over-performance (high performance and low importance). The extra efforts should be made on the attributes in the former situation, the attributes in the latter can be diagnosed as an area of inefficiency where a remedial action of the cost-cutting decision may be in demand. However, the attributes plotted in the quadrant B: keep the good work suggest the status of competitive advantages which have to be maintained (i.e. high importance and high importance), while the attributes in the quadrant D: low priority represent a minor weakness (i.e. low performance and low importance). Consequently, decision makers should focus their managerial efforts on the attributes in the quadrant A to obtain their strengths and competitive advantages in the industry. Fig. 1 (b) is a combined IPM model of the scale-centred quadrants (Martilla and James, 1977) and diagonal line model (Bacon, 2003) introduced by Abalo et al. (2007). One distinct difference from the original IPM (Martilla and James, 1977) is that the scale-centred diagonal line model enlarges the quadrant A: concentrate here, so that decision makers can distinguish a significant difference between the attributes. The interpretation of each quadrant is the same as the original one. It is noteworthy that the different grid partitions and cross-hair points deliver various results notwithstanding the same inputs of importance and performance (Oh, 2001; Azzopardi and Nash, 2013; Lai and Hitchcock, 2015).

Another contemporary issue in implementing IPA is the measurement of attributes importance, concerning with the reliability of importance rate. The controversy between two approaches, a direct measurement method (i.e. absolute importance) and indirect measurement method (i.e. relative importance), has become apparent. The direct importance is a mean importance value of metric ratings or Likert scale evaluated by respondents on each attribute. Thanks to its simple and effective calculation, the direct importance method is popularly used in IPA applications (Lai and Cheng, 2003; Tonge and Moore, 2007; Brooks et al., 2011). However, this method generally inflates importance ratings of most attributes and the attributes are displayed with 'ceiling effects' at the top of the IPA grid. This small variance in importance scores can be generated because a set of crucial attributes that are selected, prior to the survey for importance assessment, by a panel of an expert group or by reviewing previous literature (Martilla and James, 1977). In addition, Oh (2001) points out that assuming no trade-off or comparison among attributes fails to reflect competitive business environments. To avoid the problem, the indirect measurement method deems to be an alternative approach in a number of studies (Oh, 2001; Gustafson and Johnson, 2004; Lai and Hitchcock, 2015). The indirect importance is mostly based on statistically derived means (i.e. standardised regression (or correlation) coefficients) using various regression methods (e.g. Matzler et al., 2004; Deng 2007; Lee and

Hu, 2012). However, this method has also revealed some drawbacks when it exists multicollinearity, non-linear and/or interaction effects and the negative effect of below-average item performance (Lai and Hitchcock, 2015, p. 245). Furthermore, Bacon (2003) indicates that the direct measurement method performs better than the indirect measurement method including correlation and regression methods.

The findings from the above discussion suggest that there is no agreement on which method is superior to the others, although many claim that the methods applied for their studies are suitable for an empirical investigation. To this end, it would be much-recommended determinant that whether the method is well-matched in the research goals and contexts due to the coexistence of its strengths and weaknesses. This study adopts AHP since the concept is proven to be appropriate in the intensely competitive industry, and to avoid the 'ceiling effects'. The CTLs industry is a market where port users constantly compare port's service quality and/or measure whether the offerings meet their demands. To our best knowledge, AHP is for the first time incorporated as a measurement tool for attributes importance into IPA empirical setting. In the classical IPA, assessment of the attributes' importance weights does not guarantee the evaluation reliability between the attributes (e.g. mostly in absolute measurement method). AHP (Saaty, 1980) is found to be a suitable method for evaluating the relative importance of the attributes through assuring the consistency of expert's judgement with a consistency ratio (CR) of all pair-wise comparisons (Ha and Yang, 2017). In addition, this study incorporates AHP into an IPA grid method of the data-centred quadrants (Martilla and James, 1977) by referring to the literature associated with use of IPA in the transport and port domains (e.g. Lai and Cheng (2003) and Lee and Hu (2012)).

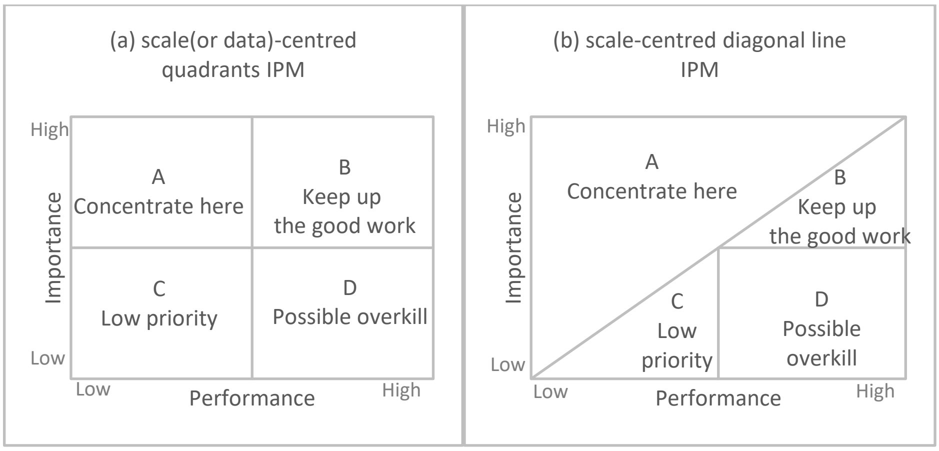

Fig. 1. Different IPA matrices

2.3.Korean container port industry and port policy

The South Korean port industry is growing its importance, particularly, in a country with an international trade-oriented economy. Especially the four ports in South Korea have played an important role in facilitating the Korean economy, covering the cargoes generated from their geographically adjacent area. Busan Port (both Busan New and North) is located in the South-Eastern corner of South Korea. Gwangyang is located in South-West while Incheon is located in the North-Western corner of South Korea, respectively. However, container traffic is more concentrated in Busan port (both Busan New and Busan North) than the two other ports. According to BPA (2017), as of 2016, Busan port has served 531 regular weekly container services to North-East Asia (151 services), America (143 services), South-East Asia (138 services), Europe (34 services) and others (65 services). Gwangyang and Incheon ports have respectively served 89 and 47 weekly services, but their services have limitedly focused on only the routes to North-East Asia (Gwangyang: 44, Incheon: 25) and South-East Asia (Gwangyang: 28, Incheon: 20). As seen in Table 1, since Busan New port development based the Korean port master development plan attempting to achieve hub-port status in North-East Asia (KMPH, 1989), more than half of currently available dedicated container terminals in South Korea have started their operations since the mid-2000. With the Korean port policy of "logistics hub strategy in the North-East Asia" in 2003 (also called a two-port system), Gwangyang port has strengthened its port function with new container terminals, expansion of its hinterland and new inland transport infrastructure (Yang and Chen, 2016). But in fact, its performance is not impressive in terms of container throughput. In line with the port development plan, Incheon new container terminals have developed in the outer harbour area in order to replace its port function of conventional terminals in the inner harbour area. These extensive new port developments have resulted in overcapacity problems, indicating high inter-port competition not only among Korean ports but also among ports in North-East Asia. In addition, the terminals in each port have been operated by different TOC, which leads to an intense intra-port competition. Accordingly, it is found that the terminal handling price per TEU in the ports was significantly cheaper than ports in both China and Japan (Seo and Park, 2016). According to Yang and Chen (2016), container handling charge per TEU in Busan port is about USD 30, whilst Gwangyang port is 60% lower than those of Busan port. This status of Korean port system has brought a huge loss of profits for TOCs as well as a negative national wealth (Park and Seo, 2015). This indicates that port managers and policy-makers should pay attention to tackle the given problems through diagnosing the strength and weakness of the ports and investigating port stakeholders' perception against received port services and activities as a proxy to reconcile the conflicts of their interests.

Table 1 Dedicated Container terminals in South Korea

Port	Terminal	Operator	Capacity of berth	Annual handling capacity (teu)	Berth length (m)	Opening year	Note
Busan North	Jasungdae	Korea Hutchison	4,000TEUx4 / 700TEUx1	1,700,000	1,447	1978	
	Shinsundae	CJ Korea Express	4,000TEUx5	2,000,000	1,500	1991	
	Gamman	SBTC, BGCT	4,000TEUx4	1,560,000	1,400	1998	
	Singamman	Dongbu Busan	4,000TEUx2 / 400TEUx1	780,000	826	2002	
	Uam	Uam Co., Ltd	2,000TEUx1 / 400TEUx2	300,000	500	1996	Closed in 2016
	Gamcheon	HanJin		660,000	600	1998	Closed in 2009
Busan New	1-1	PNIT	4,000TEUx3	1,380,000	1,200	2006	
	1-1, 2	PNC	4,000TEUx6	2,730,000	2,000	2009	
	2-1	HJNC	4,000TEUx2 / 2,000TEUx2	1,600,000	1,100	2009	
	2-2	HPNT	4,000TEUx2 / 2,000TEUx2	1,600,000	1,150	2010	
	2-3	BNCT	4,000TEUx4	1,920,000	1,400	2011	
Gwangyang	1		4,000TEUx2	1,600,000	1,400	1998	Transferred to general berth in 2013
	2-1	HSGC	2,000TEUx2 / 4,000TEUx2	1,140,000	1,150	2002	

	2-2	KIT	2,000TEUx2 / 4,000TEUx2	1,140,000	1,150	2004	
	3-1	Korea Express	4,000TEUx4	1,600,000	1,400	2007	
Incheon	SICT	SICT	1,500TEUx2	240,000	407	2009	
	E1CT	E1CT	2,000TEUx1	140,000	259	2009	
	Korea Express	Korea Express	400TEUx2	100,000	225	2009	
	HJS	HJS	10,000 ton x1/20,000 ton x1 /50,000 ton x1/40,000 ton x1	240,000	625	1996	Multipurpose berth

Source: Ministry of Land, Transport and Maritime Affairs (2013)

3. Methodology

The IPA framework in the context of CTLs is illustrated in Fig.2. In the first step, this study classifies three groups of port stakeholders in the CTLs industry. Then, the relevant activities and interests of stakeholders are defined and they are translated into corresponding port performance indicators (PPIs) for each stakeholder group to evaluate the CTLs performance of four major container ports in South Korea. The 'level of importance' for the PPIs is evaluated by a panel of ten experts using AHP, while the 'level of performance' is differently evaluated in terms of PPIs' types (i.e. quantitative and qualitative PPIs). The discrepancy of performance values between quantitative and qualitative PPIs are unified using a transformation technique. The PPIs importance and the performance of the four ports against each PPI can be used as the inputs in the IPA application. In addition, this study uses the data-centred quadrants approach based on the actual mean scores of importance and performance of all PPIs to determine cross-hair points in the IPM. The IPA framework is explained in subsections 3.1, 3.2 and 3.3 in details.

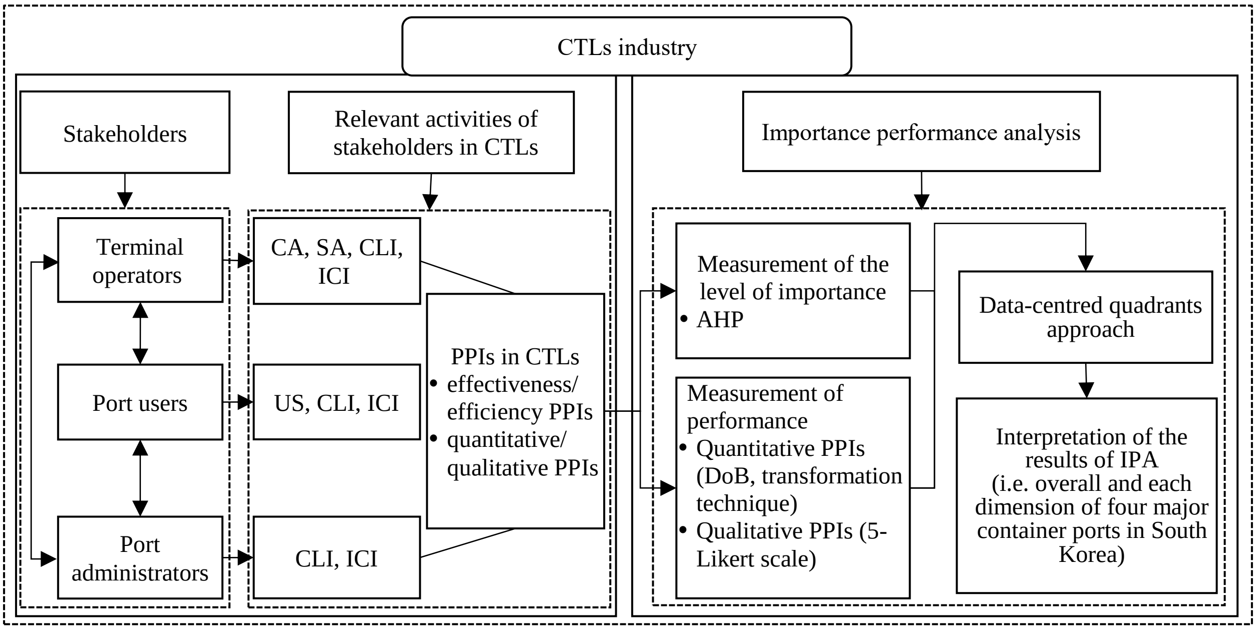

Fig. 2. Importance-Performance analysis (IPA) framework in CTLs

3.1.Classification of port stakeholders

The objective of this section is to define and classify port stakeholders in terms of their corresponding activities and the associated interests in the CTLs. The classification defined here is simplified given the fact that this study mainly focuses on the physical movements of container cargos in the CTLs. At the same time, it is noteworthy that the proposed stakeholder classification is based on the landlord port model which is a dominant type for port governance. As discussed earlier, in the landlord port model, the roles of TOCs are highly appreciated for achieving port efficiency and effectiveness. Therefore, TOCs are defined as a key player and their performance is measured by taking perspectives from the following stakeholder groups. To this end, the performance evaluations are conducted by both a self-assessment and a third-party-assessment of associated stakeholders. The classification of port stakeholders includes three groups of terminal operators (TO), port users (PU) and port administrators (AD), and they can be described as follows (Notteboom et al., 2015; Ha et al., 2017b):

- Terminal operators: they hold a right to operate and provide container handling services to port users based on concession or lease agreement in the port area.
- Port users: they are not only purchasers of port services but also influencers on the delivery of those services in the CTLs chain. They include shipping lines, ship and cargo agents, logistics service providers, freight forwarders, and road hauliers, etc.
- Port administrators: they enforce the operation of port systems (i.e. standard, regulations, etc.) within the port area. They are mostly public bodies such as port authority and central/local governments.

3.2.Port performance indicators for stakeholder management tool

To measure port performance in the context of CTLs, PPIs identified by Ha et al. (2017b) are revisited to eliminate those of no direct or crucial relevant to CTLs. Besides, some indicators were adjusted with regards to the CTLs activities by a group of experts[1]. For instance, 'financial strength' of TOCs used in Ha et al. (2017b) for port performance measurement (PPM) has apparently no direct relevant to the CTLs context. The refined PPIs are associated with port operational efficiency and effectiveness that are salient features influencing the inter-stakeholder relations in CTLs. The indicators are specific to each of the three stakeholder groups, despite the existence of some common indicators fitting all three groups. For example, 'users' satisfaction' is a specific dimension for the port user group while 'container logistics integration' is a common dimension for the three groups of port stakeholders. Consequently, the input data relating to the specific PPIs can be collected from the associated stakeholders. For the PPM in CTLs contexts, 5 dimensions, 10 principal-PPIs and 36 PPIs are defined in Table 2. The dimensions relate to 1) the extent to which the container port/terminal operates effectively and efficiently in its core function, e.g., vessel operation, cargo operation and other activities regarding container transfer or transit from ports to vessels and other transport modes (or vice versa) in container terminal area (core activities); 2) the extent to which the container

[1] They include (1) 6 industrial experts who have been working in the shipping and port industries for more than 15 years with PhD (1 expert from a shipping line), MSc (3 experts from terminal operators, a shipping line and a forwarder) and BA (1 from a terminal operator and a forwarder, respectively) degrees respectively (2) 2 professors who have more than 15 years research experience in port operations and management (3) 2 experts from government/port authorities (1 department manager and 1 managing director) who have been working for port logistics departments. It is noteworthy that they are also invited to evaluate the 'level of importance' on PPIs based on an AHP technique.

port/terminal has reliable internal resources (e.g. intangible assets such as human resources) to improve an organization's effectiveness and/or efficiency (supporting activities); 3) the extent to which the port users are satisfied with port/terminal services delivered and service price (users satisfaction); 4) the extent to which the port/terminal integrates its container logistics chain (container logistics integration); 5) the extent to which the port/terminal builds reliable information and communication systems and also realises an information and communication integration by collaborating with logistics channel members (information/communication integration). These dimensions, their associated principal-PPIs and PPIs at the bottom level in the hierarchy are evaluated as crucial for port performance measurement in the CTLs context based on currently available port performance literature and best practices in major container ports all around the world. Therefore, the selected PPIs can be interpreted as the common objectives of TOCs and PAs that unconditionally provide high-end port services to attract port users and to make their port competitive by reconciling the needs of internal and external port stakeholders.

Table 2 Port performance indicators (PPIs) in container transport logistics (CTLs)

Dimensions	Principal-PPIs	PPIs	Literature	Note[1]
Core activities (CA)	Productivity	Berth occupancy (PD1)	UNCTAD, 1976; De monie, 1987; Cullinane et al., 2002; Brooks, 2006; Woo el al., 2011	QT; Data input from TO and PA database
		Crane efficiency (PD2)		
		Yard utilization (PD3)		
		Labour utilization (PD4)		
	Lead time	Vessel turnaround time (LT1)		
		Truck turnaround time (LT2)		
		Container dwell time (LT3)		
Supporting activities (SA)	Human capital	Knowledge and skills (HC1)	Marlow and Paixão Casaca, 2003; Kaplan and Norton 2004; Alavi et al., 2006; Brown et al., 2011; Woo et al. 2013	QL; Data input by TO
		Capability (HC2)		
		Training and education opportunity (HC3)		
		Commitment and Loyalty (HC4)		
	Organisation capital	Culture (OC1)		
		Leadership (OC2)		
		Alignment (OC3)		
		Teamwork (OC4)		
Users' satisfaction (US)	Service reliability	Responsiveness to special requests (SR1)	Marlow and Paixão, 2003; Woo et al., 2011; Brooks and Schellinck, 2013	QL, Data input by PU
		Accuracy on documents & information (SR2)		
		Incidence of cargo damage (SR3)		
		Incidence of delay (SR4)		
	Service costs	Overall cost of container loading/discharging and (re)stows and other ship operations (i.e. hatch cover locking/unlocking, reefer plug/unplug on board vessel) except for lashing, tally, line handling, vessel dockage (SC1)		
		Container handling charges at CY (yard move, gate move, reefer services, storage, etc.) (SC2)		
		Cost of terminal ancillary service (flat rack bundling, applying/removing labels, sealing containers, container weighing, inspection fee, leaking tray rental, etc.) (SC3)		
Container logistics integration	Intermodal transport systems	Sea side connectivity (ITS1)	Notteboom and Rodrigue, 2005; Panayides and Song,	QL, Data input by TO, PU and AD
		Land side connectivity (ITS2)		
		Reliability for multimodal operations (ITS3)		

(CLI)		Efficiency of multimodal operations (ITS4)	2009; ESPO, 2010; Ferrari et al.; Woo et al., 2013	
	Value-added services	Facilities for adding value to cargoes (VAS1)		
		Service adaptation to customers (VAS2)		
		handle different types of cargo (VAS3)		
		capacity to launch tailored services (VAS4)		
Information/ communication integration (ICI)	IC systems	IT systems (ICS1)	Kaplan and Norton 2004; Albadvi et al., 2007; Panayides and Song, 2009; Woo et al. 2013	QL, Data input by TO, PU and AD
		Databases (ICS2)		
		Networks (ICS3)		
	IC integration practices	Integrated EDI for communication (ICP1)		
		Integrated IT to share data (ICP2)		
		Collaborate with channel members (ICP3)		

[1]Note: QT, quantitative PPI; QL, qualitative PPI;

3.3. *Application of Importance-performance Analysis*

The PPIs evaluations need to be conducted to assess the 'level of importance' and the 'level of performance' for using IPA of empirical investigation. The PPIs importance was measured prior to the PPIs performance of the four ports in Korea as Martilla and James (1977) suggested. This study adopts an AHP technique to evaluate PPIs' importance using pairwise comparisons between the PPIs. The 10 panel of experts[2] were requested to respond to a question such as "which PPI should be emphasized more in a PPM in a CTLs context, and how much more?" The AHP questionnaire was designed to facilitate a series of pair-wise comparisons grounded on the Saaty's nine-point scale ranging from 1 (equal) to 9 (extreme). In the AHP application, the evaluations of the experts need to be verified with the CR of 0.1 or less otherwise the experts are asked to revise their pairwise judgements. The judgements of five among the ten evaluators have informed with an acceptable level with the CR of 0.10 or less in the first survey. The remaining 5 experts have verified with an acceptable CR level in the second round survey. Table 3 demonstrates the local weights of criteria in a multi-level structure and the global weights of the bottom level PPIs judged by ten evaluators. We first obtained the local weights of criteria in each level and then calculated the global weights ($\sum_{i=1}^{36} w_i = 1$)of the bottom level criteria by multiplying their local weights with the ones of their associated upper-level criteria. The local weights of the five dimensions (i.e. core activities, supporting activities, users' satisfaction, container logistics integration and information/communication integration) are evaluated as 0.239, 0.153, 0.229, 0.195 and 0.185 respectively. Core activities and users' satisfaction are evaluated to be the most crucial dimensions, and followed by container logistics integration and information/communication integration. However, internal satisfaction is considered to be the least important dimension. The local weights of the principal-PPIs are shown in the second column of Table 3. The local weights of the bottom level PPIs are considered that crane efficiency (0.384) is the most important PPI in the first cluster; vessel turnaround time (0.526); training and education opportunity (0.329); teamwork (0.313); incidence of cargo damage (0.267); overall cost of using the terminal (0.537); sea side connectivity (0.361); facilities for adding value to cargoes (0.297); IT systems (0.355); integrated EDI for communication (0.344) in each cluster, respectively at the bottom level.

The global weights of the bottom level PPIs which use for IPA demonstrate that '(2) crane efficiency' is the most important PPI, which has a relative importance value of 0.0568 (i.e. 5.68

[2] Please refer to the footnote 1 for the experts' information.

out of 100), followed by '(5) vessel turnaround time (0.0479)', '(18) incidence of cargo damage (0.0417)', '(19) incidence of delay (0.0409)' and '(20) overall cost of using the terminal (0.0387)', as shown the top 5 ranking PPIs in terms of their global weight.

The service cost and its competitiveness is crucial but not as important as the service reliability. This finding is partially in accordance with the common results in port selection/ competitiveness studies that shipping lines are likely to choose a port due to the port's service timeliness and reliability including the incidence of delay (Ng, 2006; Woo et al, 2011; Brooks and Schellinck, 2013). However, one distinct result from the previous studies is 'incidence of cargo damage'. We believe that it is because of the fact that the survey for PPIs' weight evaluation was conducted a few months later (from October 2014 to November 2014) of the Sewol Ferry Disaster in Korea, occurred on 16 April 2014, which has resulted in public trauma in reaction to any kind of accident or incident occurred (Woo et al, 2015). This shocked circumstance influenced the PPIs' weight evaluations in this work. Unlike previous studies, the result is uniquely driven by a certain circumstance, hence needs to be carefully interpreted and justified through further longitudinal studies as long as the CR attained.

In the AHP analysis, on the other hand, the global weights of the PPIs are enormously dependent on the local weights of their associated upper principal-PPIs and dimensions, notwithstanding there is not great weight difference between PPIs at the bottom level. The high relative importance of two dimensions (core activities, 0.239; users' satisfaction, 0.229) and their associated principal-PPIs (productivity, 0.619; service reliability, 0.684) affects more on the global weights of their associated bottom level PPIs than other three dimensions do. However, despite the fact that the local weight of vessel turnaround time (0.526) and overall cost of container loading/discharging, (re)stows and other ship operations (0.537) shows the significant weight difference between PPIs in the same cluster, they rank second and fifth due to the low importance of their associated principal-PPIs (lead time, 0.381; service costs, 0.316).

The five least important PPIs are '(22) cost of terminal ancillary service (0.0117), '(12) culture (0.0133)', '(11) commitment and loyalty (0.0149), '(14) alignment (0.0150) and '(8) knowledge and skills (0.0180)'. The top 10 PPIs consist of three PPIs under core activities, five PPIs under users' satisfaction, one PPI each under container logistics integration and information/ communication integration, respectively. It should be noted that the obtained PPIs' importance can be changeable when the evaluations are made by a different number of stakeholders or under different circumstances (i.e. sample number, experts' geographic domain and market condition). The global weights of the bottom level PPIs are being widely spread in between 1.17% (i.e. the lowest importance) and 5.68% (the highest importance), representing no 'ceil effects' of PPIs' importance.

As seen in Table 2, the PPIs involve both quantitative and qualitative PPIs which can be measured using various types of numeric and subjective data. In terms of PPIs' types, the relevant data was collected in a different way. On the one hand, the stakeholders' perceptions on port performance with respect to each qualitative PPI were assessed on a five-point Likert scale ranging from 1 (very poor/strongly dissatisfied) to 5 (very good/strongly satisfied). The survey was conducted through an online survey tool as well as distributed by emails. The stakeholders evaluated on their associated PPIs as discussed in section 3.2. 138 valid responses were collected from the TO group, indicating 28 from Busan New Port, 31 from Busan North Port, 40 from Gwangyang Port and 39 from Incheon Port. For the survey to port users, the lists of shipping lines were obtained from the Korea Ship-owners' Association (KSA) and database systems in each port authority. The samples were chosen and sorted in terms of their ports of call in Busan New Port, Busan North Port, Gwangyang Port and Incheon Port, respectively. On top of that, the lists of other port users including third-party logistics providers, freight forwarders, and ship and cargo agents were obtained from the Korea International Freight Forwarders Association (KIFFA) and the Korea Integrated Logistics Association (KILA). 203 valid responses were collected from the PU group, indicating 84 from shipping lines and 119 from other PUs. 25 valid responses were collected from the AD group, representing 13 from port authorities and 12 from the central/local governments. Table 4 demonstrates the response details. On the other hand, the PPIs also require various types of numeric data to evaluate the quantitative PPIs of the 'productivity' and 'lead-time'. These data were collected directly from TOCs and information systems/databases managed by port authorities and the Korean governments. However, the numeric-scale varies in terms of each quantitative PPI[3] (i.e. {leq 20 lifts, 25 lifts, 30 lifts, 35 lifts, geq 40 lifts} for 'crane productivity/hr' and {$\geq$ 5 days, 4 days, 3days, 2days, $\leq$ 1day} for 'vessel turnaround time', etc.). This discrepancy in a measurement-scale, not only between quantitative PPIs but also between quantitative PPIs and qualitative PPIs, needs to be transformed and standardised in a unified manner.

Table 3 Local weights and global importance of PPIs

Dimension (local weight)	Principal-PPIs (local weight)	PPIs (local weight)		Global weight	Ranking
Core activities (0.239)	Productivity (0.619)	1	Berth occupancy (0.226)	0.0333	9
		2	Crane efficiency (0.384)	0.0568	1
		3	Yard utilization (0.192)	0.0284	16
		4	Labour utilization (0.198)	0.0293	15
	Lead time (0.381)	5	Vessel turnaround time (0.526)	0.0479	2
		6	Truck turnaround time (0.257)	0.0234	22
		7	Container dwell time (0.217)	0.0197	30
Supporting activities (0.153)	Human capital (0.527)	8	Knowledge and skills (0.223)	0.0180	32
		9	Capability (0.263)	0.0212	27
		10	Training and education opportunity (0.329)	0.0265	19
		11	Commitment and loyalty (0.185)	0.0149	34
	Organisation capital (0.473)	12	Culture (0.184)	0.0133	35
		13	Leadership (0.295)	0.0213	26
		14	Alignment (0.208)	0.0150	33
		15	Teamwork (0.313)	0.0226	23
Users' satisfaction (0.229)	Service reliability (0.684)	16	Responsiveness to special requests (0.246)	0.0384	6
		17	Accuracy on documents & information (0.226)	0.0354	8
		18	Incidence of cargo damage (0.267)	0.0417	3
		19	Incidence of delay (0.262)	0.0409	4
	Service costs (0.316)	20	Overall cost of container loading/discharging and (re)stows and other ship operations (0.537)	0.0387	5
		21	Container handling charges at yard (0.301)	0.0217	25
		22	Cost of terminal ancillary service (0.162)	0.0117	36
Container logistics integration (0.195)	Intermodal transport systems (0.534)	23	Sea side connectivity (0.361)	0.0376	7
		24	Land side connectivity (0.197)	0.0205	29
		25	Reliability for multimodal operations (0.227)	0.0236	21

[3] The numeric-scale of the 'crane productivity' is defined based on Rankine (2003), Goussiatiner (2007), Hanam Canada Corporation (2008) and five years' data (2010-2014) of 10 TOCs in Korean major container ports. The scale of the 'vessel turnaround time' was defined based on Mwasenga (2012), Ducruet and Merk (2013) and five years' data (2010-2014) of 10 TOCs in Korean major container ports. And then the panel of 10 experts confirm whether the defined scale for each quantitative PPI is applicable.

		26	Efficiency of multimodal operations (0.215)	0.0224	24
	Value-added services (0.466)	27	Facilities for adding value to cargoes (0.297)	0.0269	18
		28	Service adaptation to customers (0.207)	0.0187	31
		29	Handle different types of cargo (0.229)	0.0207	28
		30	Capacity to launch tailored services (0.268)	0.0243	20
Information/ communication integration (0.185)	IC systems (0.483)	31	IT systems (0.355)	0.0318	12
		32	Databases (0.328)	0.0294	14
		33	Networks (0.316)	0.0283	17
	IC integration practices (0.517)	34	Integrated EDI for communication (0.344)	0.0330	10
		35	Integrated IT to share data (0.333)	0.0319	11
		36	Collaborate with channel members (0.323)	0.0309	13
Sum (Mean) value				1.00 (2.76)	

Table 4 Response details

	Busan New			Busan North			Gwangyang			Incheon			Total		
	TO	PU	AD	TO	PU	AD	TO	PU	AD	TO	PU	AD	TO	PU	AD
Received by emails	4	38 (11)	0	2	38 (11)	0	40	26 (8)	(7)	0	15 (10)	(2)	46	157	9
Received by online surveys	26	20 (13)	(9)	30	20 (13)	(9)	0	5 (11)	0	41	26 (13)	(7)	97	121	25
Total responses	30	58 (24)	(9)	32	58 (24)	(9)	40	31 (19)	(7)	41	41 (23)	(9)	143	278	34
Valid responses	28	43 (15)	(6)	31	43 (15)	(6)	40	29 (13)	(7)	39	28 (17)	(6)	138	203	25
Judgement on:													SA, CLI, ICI	US, CLI, ICI	CLI, ICI

Note: This study combined the data collected in Ha et al. (2017a) as well as the data of 'CLI' from AD group, 'IC systems' from both PU and AD groups and 'IC integration practices' from AD group for two months from August 2016 to October 2016. The numbers in brackets denote the newly collected data.
The abbreviations in "judgment on" are the PPIs in Table 2 including SA (supporting activities), US (user satisfaction), CLI (container logistics integration), ICI (information and communication integration).

According to Ha et al. (2017b), the performance judgements for the quantitative PPIs with respect to each port can be presented by degrees of belief (DoB) using a location measurement technique introduced by Yang et al (2009)[4]. For example, if 'crane productivity' is 33 lifts/hr, then it belongs to 40% 30 lifts and 60% 35 lifts[5]. It can also be represented as: $H^{CP} = \{(\leq\ 20\,\text{lifts}, 0), (25\, lifts, 0), (30\, lifts, 0.4), (35\, lifts, 0.6), (\geq\ 40\, lifts, 0)\}$. Accordingly, the DoBs are converted to a five-point scale ranging from 1 to 5 (Riahi et al, 2012). It is noteworthy that the 'crane productivity' of the '≤ 20 lifts' in the numeric-scale is said to be equivalent to a grade '1 (very poor/strongly dissatisfied) in the five-point scale. In the same manner, the others are equivalent to '2 (poor/dissatisfied), 3 (neutral), 4 (good/satisfied) and 5 (very good/very

[4] Any quantitative number $h_{j,i}$ (with an evaluation grade H_j) is evaluated between $h_{j-1,i}$ (with an evaluation grade H_{j-1}) and $h_{j+1,i}$ (with an evaluation grade H_{j+1}) using the equation below.

$$If\ h_{j-1,i} < h_{j,i} < h_{j+1,i}\ then\ B_{j+1,i} = \frac{h_{j,i} - h_{j-1,i}}{h_{j+1,i} - h_{j-1,i}}, B_{j-1,i} = 1 - h_{j+1,i}$$

where $B_{j+1,i}$ represents the DoB associated quantitative number with the grade H_{j+1} and $B_{j-1,i}$ represents the DoB associated quantitative number with the grade H_{j-1}.

[5] To assess the performance of ports on PPIs, subjective judgements or numerical values can be used to differentiate one alternative port to another. In this case (i.e. crane productivity of port A), we use the concept of degrees of belief (DoB) to convert the numerical value of 100% 33 lifts/hr to 40% 30 lifts/hr and 60% 35 lifts/hr using the equation in footnote 4. The degrees of belief are originally represented by an expectation that was designed to model a subjective assessment with uncertainty. Yang et al (2009) have expanded its usage to numerical values to deal with both quantitative data and qualitative data within a single framework.

satisfied)', respectively. Therefore, the 'crane productivity' can be calculated as 3.6 ($= (0.4 \times 3) + (0.6 \times 4)$)[6]. The performance of each quantitative PPI with respect to each port was assessed in a similar manner.

Table 5 Results of performance ratings on CTLs PPIs at 4 major ports in Korea

		Performance							
		Busan New		Busan North		Gwangyang		Incheon	
	PPIs	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Berth occupancy (PD1)	1.60	-	**3.34**	-	1.00	-	2.00	-
2	Crane efficiency (PD2)	**4.06**	-	3.66	-	3.70	-	3.40	-
3	Yard utilization (PD3)	**3.35**	-	1.55	-	1.10	-	1.05	-
4	Labour utilization (PD4)	3.51	-	3.11	-	**4.80**	-	3.60	-
5	Vessel turnaround time (LT1)	**5.00**	-	**5.00**	-	**5.00**	-	**5.00**	-
6	Truck turnaround time (LT2)	**5.00**	-	4.18	-	3.91	-	3.20	-
7	Container dwell time (LT3)	**4.70**	-	4.64	-	4.03	-	4.40	-
8	Knowledge and skills (HC1)	4.07	0.54	3.87	0.55	3.68	0.65	**4.13**	0.79
9	Capability (HC2)	3.50	0.64	3.42	0.71	3.35	0.85	**3.85**	0.98
10	Training and education opportunity (HC3)	3.32	0.82	3.10	1.09	3.15	1.04	**3.74**	0.95
11	Commitment and Loyalty (HC4)	3.68	0.67	3.52	0.98	3.33	0.69	**3.90**	0.90
12	Culture (OC1)	3.68	0.61	3.45	0.98	3.36	0.77	**3.74**	0.84
13	Leadership (OC2)	**3.86**	0.76	3.74	0.98	3.53	0.77	3.77	0.95
14	Alignment (OC3)	3.54	0.64	3.61	1.01	3.60	0.83	**3.72**	0.90
15	Teamwork (OC4)	3.68	0.82	3.61	1.01	3.43	0.86	**3.77**	0.86
16	Responsiveness to special requests (SF1)	3.39	0.96	3.37	0.88	**3.80**	0.89	3.38	0.79
17	Accuracy on documents & information (SF2)	**3.76**	0.84	3.52	0.79	3.68	0.84	3.46	0.92
18	Incidence of cargo damage (SF3)	**3.78**	0.93	3.67	0.87	3.76	0.94	3.32	0.79
19	Incidence of delay (SF4)	3.50	0.84	3.20	0.74	**3.71**	0.92	3.37	0.95
20	Overall cost of container loading/discharging and (re)stows and other ship operations (SC1)	3.22	0.99	**3.33**	0.78	**3.33**	0.87	3.31	0.84
21	Cargo handling charges at CY(SC2)	3.12	0.97	3.23	0.72	**3.42**	0.77	3.33	0.82
22	Cost of terminal ancillary service (SC3)	3.00	1.00	3.20	0.79	**3.38**	0.84	3.25	0.92
23	Sea side connectivity (ITS1)	**3.65**	0.92	3.46	0.87	3.54	0.85	3.56	0.83
24	Land side connectivity (ITS2)	**3.59**	0.91	3.56	0.93	3.41	0.91	3.37	0.92
25	Reliability for multimodal operations (ITS3)	**3.70**	0.90	3.59	0.80	3.60	0.79	3.50	0.84
26	Efficiency of multimodal operations (ITS4)	**3.63**	0.89	3.46	0.78	3.48	0.82	3.39	0.90
27	Facilities for adding value to cargoes (VAS1)	**3.38**	0.96	3.17	0.99	3.24	0.88	3.14	0.99
28	Service adaptation to customers (VAS2)	**3.70**	0.87	3.38	0.92	3.51	0.83	3.23	0.95
29	Handle different types of cargo (VAS3)	3.58	0.98	3.41	0.99	**3.61**	0.86	3.39	0.92
30	Capacity to launch tailored services (VAS4)	3.53	0.93	3.30	0.88	**3.58**	0.85	3.36	0.90
31	IT systems (ICS1)	3.61	0.88	**3.77**	0.71	3.33	0.88	**3.77**	0.95
32	Databases (ICS2)	3.43	0.79	3.48	0.71	3.28	0.87	**3.77**	1.00
33	Networks (ICS3)	3.43	0.63	3.48	0.95	3.53	0.71	**3.62**	0.95
34	Integrated EDI for communication (ICP1)	**3.78**	0.81	3.64	0.77	3.64	0.89	3.55	0.84
35	Integrated IT to share data (ICP2)	**3.72**	0.83	3.57	0.83	3.53	0.95	3.47	0.83
36	Collaborate with channel members (ICP3)	3.64	0.77	3.48	0.76	3.41	0.89	**3.66**	0.84
	Mean value	3.63		3.50		3.46		3.49	

Note: The bolds in the table denote the values of a leading performer among the four ports

Table 5 summarises the means and standard deviations (for all the qualitative PPIs) in terms of the performance ratings on the PPIs at the four major container ports in Korea. The performance

[6] The scientific discipline of this transformation technique is based on the utility techniques introduced by Yang (2001) either for mapping from input at the bottom level to output at its associated upper level or for transforming from quantitative evaluation scale to qualitative evaluation scale (and vice-versa).

ratings on the PPIs throughout the ports are recognised to be high, representing the value of above 3.0 on the five-point scale except for '(1) berth occupancy rate' and '(3) yard utilisation'. Busan New Port is rated as the highest performer based on the average of the all mean values, while the other three ports show a similar level of performance. In particular, Busan New Port outperforms the others with 16 PPIs out of 36 including '(2) crane efficiency', '(3) yard utilisation, '(6) truck turnaround time' and most of PPIs under container logistics integration. Incheon Port ranks the highest performance on 12 PPIs that include most of PPIs under supporting activities and PPIs under information/communication systems and followed by Gwangyang Port with 9 PPIs and Busan North Port with 4 PPIs. However, the aim of this study is not to rank ports in a row in terms of their performance but to provide decision makers with a comprehensive guidance for performance improving decisions based on results yielded by the IPA method. The PPIs' importance and performance obtained here are hence used as the inputs in the IPA application in Section 4.

4. Results and discussion

This study provides an IPA (i.e. data-centred quadrants) of four major container ports in South Korea. The IPA implementation for this study is conducted based on the literature using an IPA on the transport and port domains (e.g. Lai and Cheng (2003) and Lee and Hu (2012)). This study uses the actual mean scores of importance and performance of all PPIs to determine cross-hair points and plots the PPIs in the four quadrants of the IPMs. It is noteworthy that we first conducted pre-tests of the three IPA grid methods in order to find an appropriate application for the study, including the data (scale)-centred quadrants (Martilla and James, 1977) and scale-centred diagonal line model (Abalo et al., 2007) as shown in Fig. 1. After thorough comparison of the three approaches, the data-centred quadrants approach is selected based on the analysis of the strengths and weaknesses of each method. For instance, if a scale-centred quadrants approach (i.e. scale mean score of 3) was used, 34 of 36 PPIs in the four ports would be plotted in quadrants B and D in the IPMs, which is not efficient to distinguish the ports' performance. On the other hand, if a scale-centred diagonal line model was used, more than half number of PPIs would be located in quadrants D, representing the status of over-performance. Consequently, we found the results obtained from both the scale-centred diagonal line and the scale-centred quadrants models were not rational and cannot be used to achieve our research objectives and interpret the relevant contents. This process would be an essential prerequisite for implementing IPA empirical settings because different IPA methods yield different results despite the same inputs of importance and performance (see Oh, 2001; Azzopardi and Nash, 2013; Lai and Hitchcock, 2015). We therefore chose the actual mean scores of importance and performance for this study, which is more suitable for the research goals and contexts.

4.1. *Overall results and findings*

The results indicate that the PPIs grouped into four quadrants show a significant similarity among the four ports. PPIs are almost equally located in the four quadrants of the IPMs (see Fig. 3). This implies that the problem regarding a causal relationship between importance and performance is addressed, indicating a good reference for decision makers in developing management suggestions. Another implication is that the 'ceil effects' of PPIs importance ratings has effectively handled as shown in Fig 3. Compared to our approach, in the traditional IPA grid (i.e. scale- and data-centred quadrants), a high positive correlation causes PPIs to scatter in the positive quadrants of the IPA (i.e. quadrants B and C), whereas a negative correlation causes PPIs to spread in the negative quadrants of the IPA (i.e. quadrants A and D). To this end, the proposed IPA method successfully tackled the discriminant validity problem, when the traditional IPA method is used (Oh, 2001; Azzopardi and Nash, 2013).

Table 6 shows the IPA results of four ports, grouping each PPI into four quadrants in terms of PPIs performance and their associated relative importance. The IPA results are very similar in terms of the number of PPI and type of PPI located in the IPM, except for Gwangyang Port where only 6 out of 36 PPIs are located in quadrant A. The similarity is significant particularly between the adjacent ports of Busan New Port and Busan North Port where they are governed by Busan Port Authority. It is highly possible because that the four Korean ports are achieving objectives alike under a similar logistics environment as Ha et al. (2017b) argued. Although some PPIs are scattered along the cross-hair lines, the findings from each dimension perspective drawn from the IPA approach can still be well used to provide insights for decision makers to diagnose their own situation.

Table 6 IPA results of four ports

Port	Quadrant A	Quadrant B	Quadrant C	Quadrant D
Busan New	1, 3, 4, 16, 19, 20, 31, 32, 33	2, 5, 17, 18, 23, 34, 35, 36	9, 10, 14, 21, 22, 24, 27, 29, 30	6, 7, 8, 11, 12, 13, 15, 25, 26, 28
Busan North	1, 3, 4, 16, 19, 20, 23, 32, 33, 36	2, 5, 17, 18, 31, 34, 35	9, 10, 12, 21, 22, 26, 27, 28, 29, 30	6, 7, 8, 11, 13, 14, 15, 24, 25
Gwangyang	1, 3, 20, 31, 32, 36	2, 4, 5, 16, 17, 18, 19, 23,33, 34, 35	9, 10, 11, 12, 15, 21, 22, 24, 27	6, 7, 8, 13, 14, 25, 26, 28, 29, 30
Incheon	1, 2, 3, 16, 17, 18, 19, 20, 35	4, 5, 23, 31, 32, 33, 34, 36	6, 21, 22, 24, 26, 27, 28, 29, 30	7, 8, 9, 10, 11, 12, 13, 14, 15, 25

1	Berth occupancy (PD1)	19	Incidence of delay (SF4)
2	Crane efficiency (PD2)	20	Overall cost of container loading/discharging, (re)stows and other ship operations (SC1)
3	Yard utilization (PD3)	21	Cargo handling charges at yard (SC2)
4	Labour utilization (PD4)	22	Cost of terminal ancillary service (SC3)
5	Vessel turnaround time (LT1)	23	Sea side connectivity (ITS1)
6	Truck turnaround time (LT2)	24	Land side connectivity (ITS2)
7	Container dwell time (LT3)	25	Reliability for multimodal operations (ITS3)
8	Knowledge and skills (HC1)	26	Efficiency of multimodal operations (ITS4)
9	Capability (HC2)	27	Facilities for adding value to cargoes (VAS1)
10	Training and education opportunity (HC3)	28	Service adaptation to customers (VAS2)
11	Commitment and Loyalty (HC4)	29	Handle different types of cargo (VAS3)
12	Culture (OC1)	30	Capacity to launch tailored services (VAS4)
13	Leadership (OC2)	31	IT systems (ICS1)
14	Alignment (OC3)	32	Databases (ICS2)
15	Teamwork (OC4)	33	Networks (ICS3)
16	Responsiveness to special requests (SF1)	34	Integrated EDI for communication (ICP1)
17	Accuracy on documents & information (SF2)	35	Integrated IT to share data (ICP2)
18	Incidence of cargo damage (SF3)	36	Collaborate with channel members (ICP3)

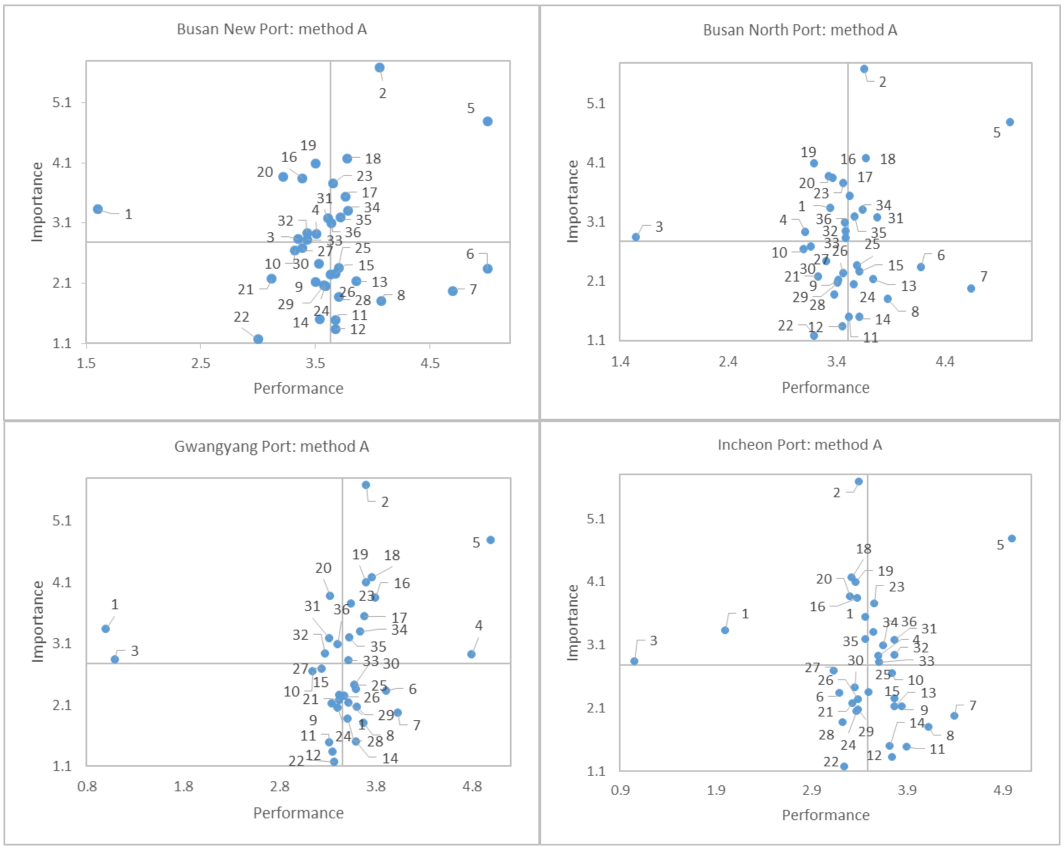

Fig. 3 IPA matrices of four ports

4.2. *Findings from each dimension*

Fig. 4 shows the IPA matrices results of the core activities (CA) dimension in Korean four ports. The quadrant B suggests that the ports performed well on crane efficiency (PD2) and vessel turnaround time (LT1). The PPIs (i.e. LT2 and LT3) in quadrant D are indicative of low importance but relatively high performance, which represents a need for resource allocation strategy. For instance, LT3 (container dwell time) of four ports are relatively short (e.g. 3-5 days denoting $>$ 4.0 performance rate), which implies that the ports may have an opportunity to generate more revenue by inducing port users to dwell their containers longer in the container yards. In turn, the practices can lead to an increased yard utilisation (PD3) notwithstanding PD3 is interpreted as low importance and low performance in quadrant C. None of the PPI is in quadrant A. The PPIs of PD1 and PD3 in all four ports, PD4 in Busan North Port and LT2 in Incheon Port are in quadrant C. IPA interprets the PPIs in quadrant C as 'low priority'. However, they are identified as very low-performance relative to their mean score of importance in terms of IP (importance performance) gap analysis (e.g. importance value minus performance value, therefore a negative number is indicative of good performance). If a diagonal line model (Bacon, 2003) was used, these PPIs would be plotted in quadrants A: concentrate here in the IPMs. The recommended strategies for the CA dimension in Korean ports are doing 'keep up the good work' for PD2 and LT1, as well as minimising 'overkill of resources' for PPIs in quadrant D. In addition, strategy for the PPIs in quadrant C should be 'concentrate here'.

Fig. 5 indicates that all PPIs of the supporting activities (SA) are plotted in quadrants A and B. However, they are mostly scattered along the cross-hair lines, forming tighter clustering of the PPIs. The PPIs should be interpreted with cautions (Azzopardi and Nash, 2013) in an IPA empirical research. The plausible interpretation would be based on Euclidian distance calculation, as they are likely to fall into the same group using by statistical technique (i.e. factor analysis) as Oh (2001) argued. To this end, the results indicate that all ports need to take action to improve the performance of the PPIs in quadrant A as well as the PPIs closed to the cross-hair in quadrant B to move their location from left to right of the IPM. The recommended strategy for the four ports is doing 'concentrate here' for most PPIs of the supporting activities. However, ironic results can be found if we were to use a scale-centred diagonal line model (Abalo et al., 2007). Fig. 1 (b) shows a combined IPM model of the scale-centred quadrants and diagonal line models, all of them would be grouped in quadrant D: possible overkill. Most intangible PPIs under the SA dimension, however, can be outperformed without pledging the overload of resources (Oh, 2001). To this end, the results shown in Fig. 5 are verified in Section 4.2.

The results of the users' satisfaction (US) dimension for the four ports are apparently a high similarity. In terms of Euclidian distance or statistical analysis perspectives, the PPIs including SF1, SF2, SF3, SF4 and SC1 are likely to fall into the same group. In addition, they are scattered along the cross-hair between quadrant A and B, which implies that all ports should pay special attention to these PPIs since evaluators' satisfaction (i.e. port users) is not very high relative to their importance. SC2 and SC3 can also be interpreted as very low customer satisfaction although their importance is relatively low compared to the other PPIs in the US dimension. This can be clearly analysed through an IP gap analysis, SC2 and SC3 both in Busan New Port and Busan North Port and SC3 in Incheon Port indicate a positive number. Therefore, the plausible strategy for the four ports is doing 'concentrate here' for most PPIs (SF1, SF2, SF3, SF4 and SC1) of the users' satisfaction.

The findings from Fig. 7 indicate that most PPIs under the CLI dimension are apparently short Euclidian distance except for ITS1. Most PPIs are located in the intersection point of four quadrants. Apparently, they can be interpreted as low importance and high-performance PPIs (in quadrant D), indicating all ports have superior seaside and landside connections to attract salient port users, logistics facility to stimulate cargo generation and customer-driven services practices. In other words, IPA interprets this situation as 'overkill'. However, interpretations should be done with cautions because most PPIs represent intangible assets (i.e. know-how, HR/organisational capacity) except for a few facilities, infra- and superstructure PPIs (i.e. ITS2, VAS1). Like the PPIs in the supporting activities, those intangible PPIs can be improved their performance without committing the overkill of resources. To this end, we recommend decision makers in the four ports to interpret the PPIs as 'concentrate here' or 'lower priority'.

Similar to the PPIs in the CLI dimension, most PPIs in the ICI dimension are concentrated on the intersection point of four quadrants, but they are relatively high important and high performance compared to the ones in the CLI dimension (Fig. 8). Most PPIs are commonly located in quadrant B. However, ICS2 and ICS3 are conflicting in terms of their location in quadrant C and quadrant D, respectively, but have a short Euclidian distance each other. To this respect, the four ports should either do 'keep up the good work' (i.e. PPIs in quadrant B) to sustain their status quo or 'no attention required at this time' (i.e. the rest of PPIs).

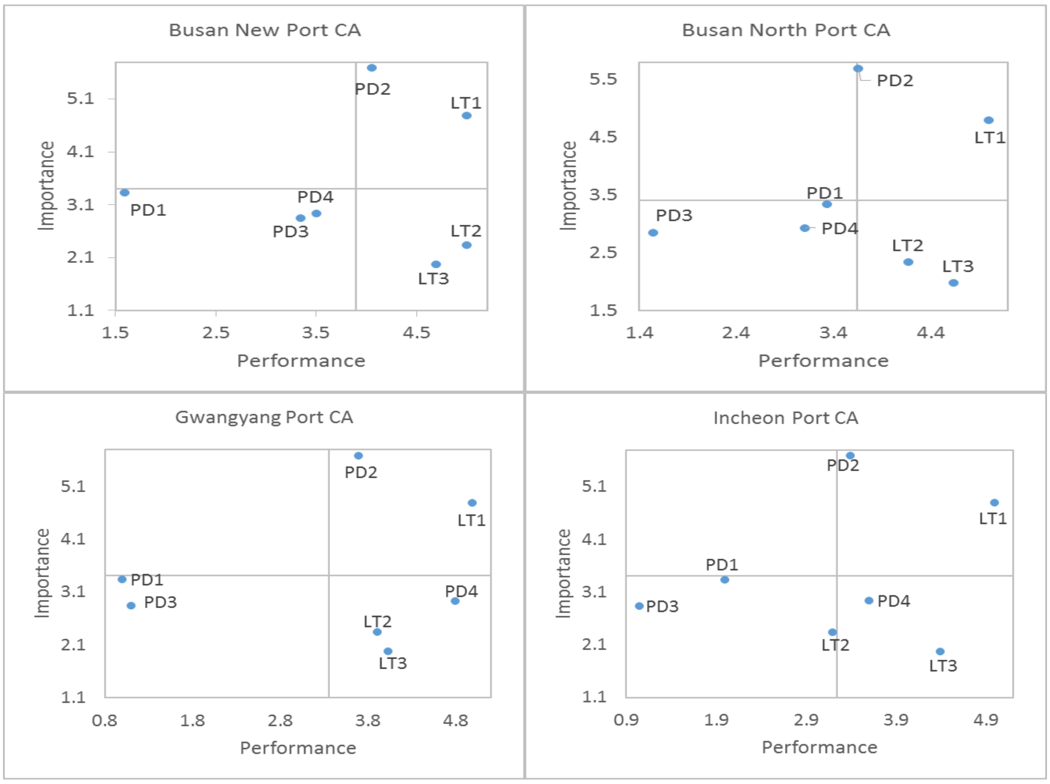

Fig. 4 IPA matrices of four ports (core activities)

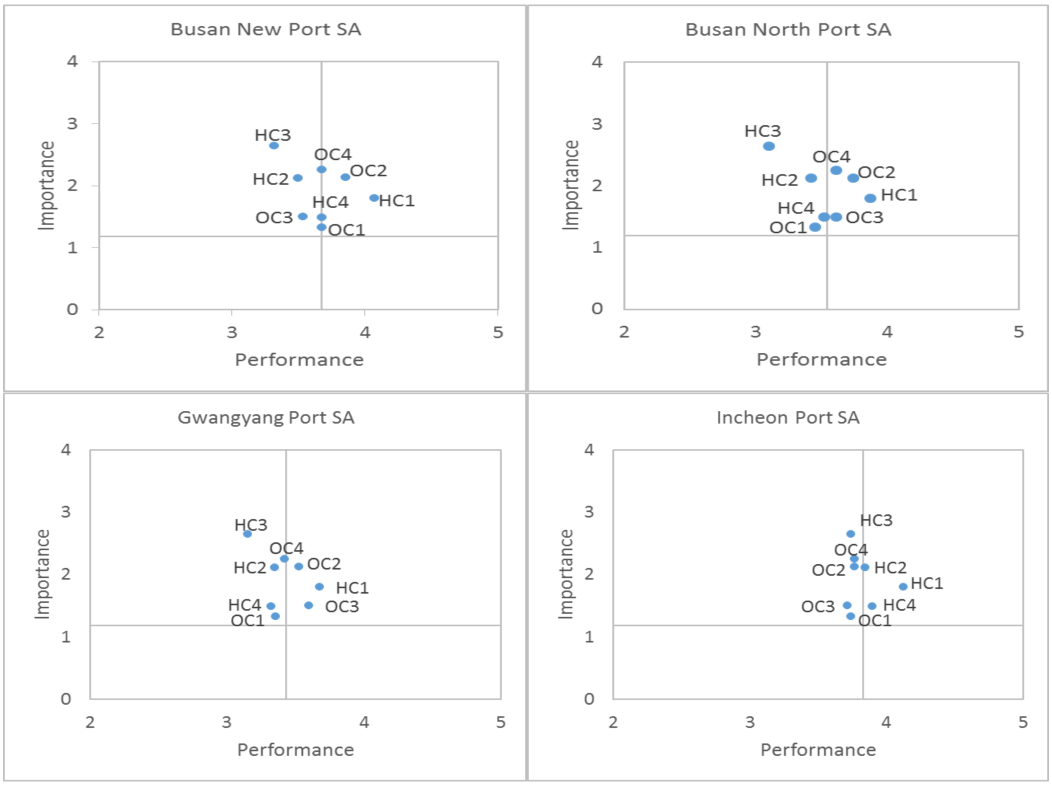

Fig. 5 IPA matrices of four ports (supporting activities)

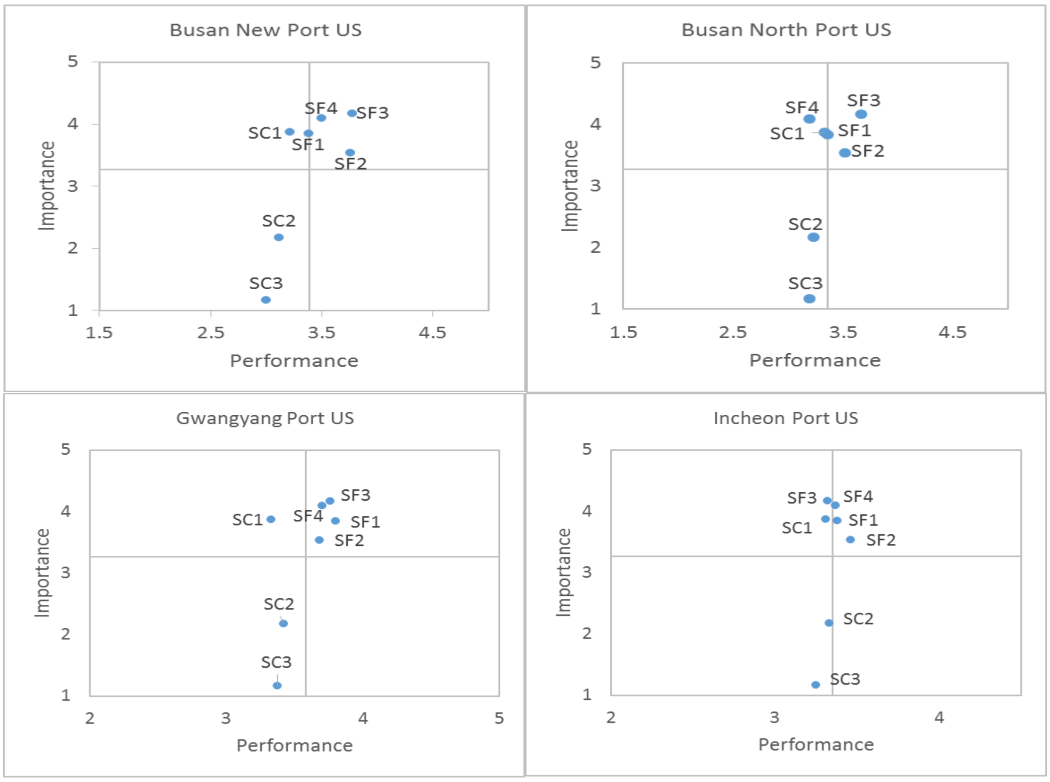

Fig. 6 IPA matrices of four ports (users' satisfaction)

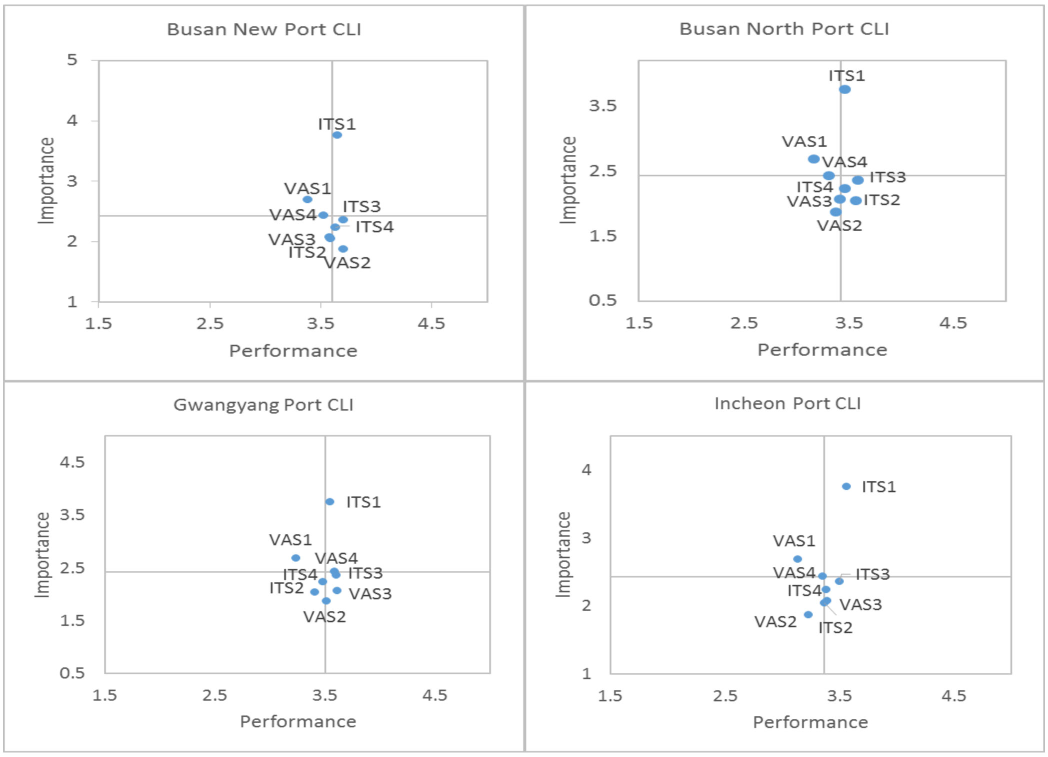

Fig 7 IPA matrices of four ports (container logistics integration)

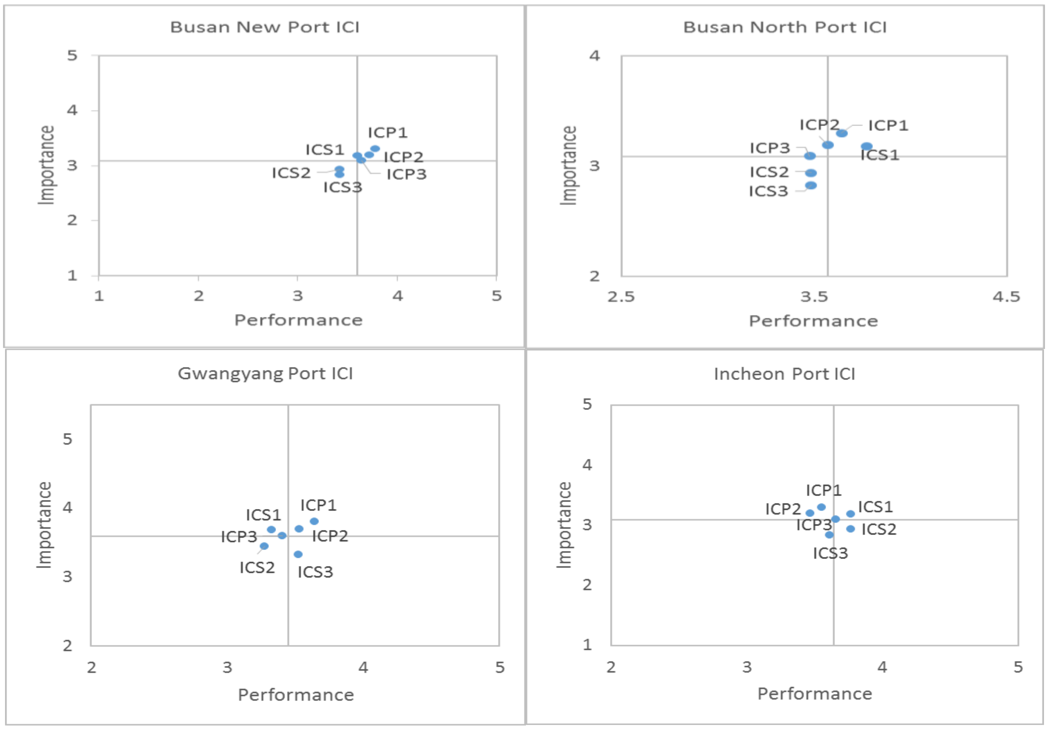

Fig. 8 IPA matrices of four ports (information communication integration)

4.3.*Practical suggestions*

This section provides practical recommendations to decision makers to assist them in establishing priority decision, in other words, how they can take strategic actions to sustain their port competitive and satisfy the expected customers' needs. The suggestions are made based on the IPA literature (Oh, 2001; Azzopardi and Nash, 2013; Lai and Hitchcock, 2015) to attempt to address the cautions when the traditional IPA method is used in an empirical research. Due to length limitations for this paper, Busan New Port is provided as an example case.

This study recommends that decision makers in each port make their decision priority from top down. For instance, the decision priority should be made firstly on the important dimension of CA and US, then on ICI, CLI and SA in sequence. Next, their attention should be paid to each individual PPI to take strategic actions for stakeholder management. We developed 13 relevant check lists to allocate the individual PPIs into four strategic actions (A: concentrate to improve, B: keep up the good work, C: lower priority, D: cost-cutting decision) in terms of PPIs points calculated from their associated lists (i.e. each list has 2 points when fully satisfied). They can be distributed when they satisfy the following conditions.

- PPIs in quadrant A: strategic action for the PPIs in quadrant A is interpreted as 'concentrate here' in which the interpretation of the strategic action is the same as the original one. Because this quadrant is the most crucial dimension where the PPIs fail to meet the level of performance that port stakeholders evaluate them as important.
- PPIs in quadrant B: even though PPI is located in quadrant B, when 'its location is near the cross-hair line between quadrant A and quadrant B' or 'its nearest PPI in terms of Euclidian distance (ED) is not located in quadrant B or indifference' or 'its importance performance (IP) gap is positive or small negative value compared to the other PPIs in the same dimension', its strategic action can be interpreted as

‘concentrate here’. Otherwise it can be interpreted as ‘keep up the good work’. For instance, SF4 (incidence of cargo delay, total points of -2) is originally plotted in quadrant B (2 point), but we interpreted it as ‘concentrate here’ because it is plotted in near the cross-hair line between quadrant A and quadrant B (-2 points), its nearest PPI in terms of ED is indifference (-1 point) and its IP gap is small negative value (e.g. -0.23) compared to the other PPIs in the dimension (e.g. SF2: -0.5, SF3:-0.51) (-1 point). Another example of ICP1 (integrated EDI for communication, total point of 1) is interpreted as ‘keep up the good work’, as it is plotted in quadrant B (2 point), it is plotted in near the cross-hair line between quadrant A and quadrant B (-2 points), its nearest PPI in terms of ED is indifference (-1 point) and its IP gap is negative value (2 points).

- PPIs in quadrant C: even though PPI is located in quadrant C, when ‘its location is near the cross-hair line between quadrant A and quadrant C’ or ‘ED between PPIs in quadrant C is longer than the one between PPI and the cross-hair line’ or ‘its IP gap is big negative value compared to other PPIs in the same dimension’, its strategic action can be interpreted as ‘concentrate here’. Otherwise it can be interpreted as ‘lower priority’. In terms of these conditions, we interpret PD1 (berth occupancy) in quadrant C as ‘concentrate here (quadrant A) while PD3 (yard utilisation) in quadrant C is interpreted as ‘lower priority (quadrant C)’ which is the same interpretation as the original one.
- PPIs in quadrant D: even though PPI is located in quadrant D, when ‘its nearest PPI in terms of Euclidian distance (ED) is not located in quadrant D or indifference’ or ‘Performance improvement without committing the overkill of resources (intangible assets), its strategic action can be interpreted as ‘keep up the good work’. Otherwise it can be interpreted as ‘cost-cutting decision’. For instance, VAS2 (Service adaptation to customers) in quadrant D is interpreted as ‘keep up the good work (quadrant B)’.

Table 7 shows the strategic actions for Busan New Port so that decision makers in Busan New Port can easily use the findings from this study. This recommendation can be applied to the other ports in the same manner. The findings from Table 7 indicate that eight PPIs (PD1, SF1, SF4, SC1, VAS1, VAS4, HC2, HC3) are located in quadrant A: concentrate here, eighteen PPIs (PD2, LT1, SF2, SF3, ICS1, ICP1, ICP2, ICP3, ITS1, ITS3, ITS4, VAS2, HC1, HC4, OC1, OC2, OC3, OC4) are located in quadrant B: keep the good work, six PPIs (PD3, PD4, SC2, SC3, ICS2, ICS3) are located in quadrant C: lower priority and four PPIs (LT2, LT3, ITS2, VAS3) are located in quadrant D: possible overkill. As we discussed before, IPA has some problems with regard to the interpretation of attributes in the IPM. However, the problem has successfully tackled through the example case of Busan New Port. The suggestions would help to clarify investment strategies for stakeholder management, especially when the decision is made for minimising risks within investment portfolios in today’s competitive logistics business environments.

Table 7 The interpretation of the IPA matrices results for taking strategic actions (Busan New Port)

		First priority														Second priority																					
		Core activities							Users' satisfaction							IC integration						Container logistics integration								Supporting activities							
Quads		PD1	PD2	PD3	PD4	LT1	LT2	LT3	SF1	SF2	SF3	SF4	SC1	SC2	SC3	ICS1	ICS2	ICS3	ICP1	ICP2	ICP3	ITS1	ITS2	ITS3	ITS4	VAS1	VAS2	VAS3	VAS4	HC1	HC2	HC3	HC4	OC1	OC2	OC3	OC4
QA	**PPI is plotted in QA?**								Y				Y			Y					Y					Y			Y		Y	Y	Y	Y		Y	Y
QB	**PPI is plotted in QB?**		Y			Y			Y	Y	Y	Y				Y			Y	Y	Y	Y								Y			Y	Y	Y		Y
QA	PPI is plotted in near the cross-hair line between QA and QB?		Y			N			-	N	N	Y				-			Y	Y	-	Y								N			-	-	N		-
QB	The nearest PPI in terms of ED is located in QB?		Y			Y			ID	Y	Y	ID				ID			ID	ID	ID	ID								Y			ID	ID	Y		ID
QB,QD	IP gap is negative value?		Y			Y	Y	Y	Y/s	Y	Y	Y/s				Y			Y	Y	Y	Y	Y	Y	Y		Y	Y		Y			Y	Y	Y		Y
QC	**PPI is plotted in QC?**	Y		Y	Y									Y	Y		Y	Y			Y		Y		Y			Y	Y								
QA	PPI is plotted in near the cross-hair line between QA and QC?	Y		N	ID									N	N		Y	Y			Y		N		N			N	Y								
QC	ED between PPIs in QC is shorter than the one between PPI and cross-hair line?	N		Y	Y									ID	Y		Y	Y			ID		ID		ID			ID	ID								
QA,QC	IP gap is positive value?	Y		Y	N				N					Y	Y	N	N/s	N/s			N		N		N			N	N/s				N	N			N
QD	**PPI is plotted in QD?**						Y	Y													Y		Y	Y	Y		Y	Y									
QD	The nearest PPI in terms of ED is located in QD?						Y	Y													N		ID	ID	ID		ID	ID									
QD	PPI represents tangible assets?						Y	Y													N		Y	N	N		N	Y									
QB	Performance improvement without committing the overkill of resources (intangible assets)?						N	N													Y		N	Y	Y		Y	N									
Strategic actions		A	B	C	C	B	D	D	A	B	B	A	A	C	C	B	C	C	B	B	B	B	D	B	B	A	B	D	A	B	A	A	B	B	B	B	B

Note: QA (quadrant A), QB (quadrant B), QC (quadrant C), QD (quadrant D), PPI (port performance indicators), ED (Euclidian distance), Y (yes, $\pm$2 points), N (no, $\pm$2 points), ID (indifference, $\pm$1 point), Y/s (yes/small IP value, $\pm$1 point), N/s (no/small IP value, $\pm$1 point) A (concentrate to improve), B (keep up the good work), C (lower priority), D (cost-cutting decision).

5. Conclusions

This study conducts an assessment of port performance by adopting the data-centred quadrants IPA method in the CTLs industry and demonstrates examples from South Korea. In implementing IPA, this study introduces an applicability of AHP as a measurement tool for assigning attribute importance. AHP is a decision-making tool that has originally designed for judgements by a panel of experts who have abundant knowledge on the research topic and area. In this respect, this study invited qualified experts for evaluating PPIs importance to overcome the difficulty of incorporating AHP in IPA in the literature. More importantly, the 'ceil effects' of the importance ratings which is a major problem observed from the traditional IPA (i.e. direct importance measurement) has effectively controlled. Using the direct measurement method based on trade-off or comparison among attributes, AHP generates relative attributes importance, making it possible and rational for IPA application in today's competitive logistics business environments. Another implication from IPA implementation is that this study tests the IPA's applicability beyond service satisfaction contexts using the attributes of different features (i.e. quantitative and qualitative). The discrepancy in measurement scales has been tackled with success too.

The findings from the empirical investigations in major container ports, South Korea suggest identical results in terms of PPIs' locations in different quadrants. Plausible explanations would be that the governance of Korean port system can be explained somewhere between the private and the private/public model (Cullinance et al., 2002) in terms of the taxonomy of port governance developed by Baird (1995, 1997). The ports (specifically TOCs) are generally in pursuing the growth of the profits or market shares. Their development and operation scheme (for newly developed terminals) in terms of a PPP (public-private partnerships) law are based on BTO (Built-Transfer-Operation) which is a sort of BOT (Built-Operation-Transfer) and a unique scheme in the context of concession agreement in South Korea. In addition, with regards to the similarity of the objectives, the case ports are under a similar logistics environment (i.e., similar organizational structure, port governance, policy and economic condition) as Ha et al. (2017b) argued. For better understating of the result, we conducted interviews with department officers/managers at Ministry of Ocean and Fisheries and port authorities in Korea. The summary of their comments is that "TOCs in each port have informally shared their performance (i.e. productivity and lead-time), which can be used for a bench-marking purpose. In addition, port authorities (i.e. Busan Port Authority) have evaluated 'annual productivity evaluations' using both quantitative (i.e. berth productivity and container throughput growth) and qualitative indicators (i.e. efficient policy on yard operation and loading and unloading process). In addition, they have implemented a survey to evaluate customers' satisfaction from port users (i.e. annual or more long-term longitudinal basis) and used the data for policy setting." The interviews offer us a viable insight on the interpretation of our findings.

Korean port system is also characterised by various port management mechanisms, particularly in the container port industry. In other words, there are various types of TOCs within a port, leading to an intense intra-port competition at an operator level (see Table 1). As seen in Table 1, for example, there were 10 TOCs in Busan port until 2009. The terminal handling price per TEU in the port is considerably cheaper than the others in both China and Japan (Seo and Park, 2016) which are about USD 30 (Yang and Chen, 2016). In a theme of the intra-port competition, the relationships between port competition and service price have been extensively discussed (Pallis and De Langen, 2006). In general, port users might attach great importance to a low service charge but with an assured service quality level. Notwithstanding there is a low terminal handling charge in Korean port system as we mentioned in section 2.3, it turns out that customers' satisfaction on various port charges (i.e. SC1, SC2 and SC3) is not high, regardless of the 4 ports. However, they are mostly satisfied with the service fulfilment PPIs (i.e. SF1, SF2, SF3 and SF4) that are located in quadrant B. The finding suggests that being cost competitive is a necessary but not sufficient condition for meeting the customers' satisfaction in the CTL context. The similar finding has been found in a maritime supply chain (Lam, 2015). According to Ha et al. (2017a), the underlining problems of Korean port system have seemed to be driven by more external (i.e. government policy, shipping alliance and mega-vessel) than internal perspectives (i.e. TOC's internal problems). This situation is beyond of the terminal business activities, which may be hard to address in terms of TOC's internal business practices, but would be more effectively solved when the objectives of TOCs and PAs are coincided and through focusing their resources on the PPIs located in a modified quadrant A in Table 7.

The main originality of this study is the development of a measurement instrument to provide managerial and operational insights to both port managers (i.e. TOCs) and policy makers (i.e. PAs and government) for stakeholder management in the CTLs. Unlike the ones from other regions/counties, the PAs in South Korea keep managerial and operational functions in their own hands (as a landlord and policy maker in port management and operation), however the regulatory authority is controlled by the Ministry of Oceans and Fisheries (MOF) and its regional offices. Therefore, the results obtained in this study are useful for both port managers and policy makers in prioritising their management strategies to achieve competitive advantages over the competitors in the industry. It is particularly important when the objectives of TOCs and PAs are coincided in providing high-end port services to attract port users and making their port competitive. The results by taking the perspectives from different port stakeholders in CTLs industry would provide decision makers with useful information for managing salient port stakeholders, taking into account the objectives and interests of different stakeholder groups. The findings from Table 7 can contribute to practitioners and regulators in the following ways. First, the stakeholder management principles should be applied based on the descending order of the important dimension. For instance, decision makers in Busan New Port should put the first priority on the core activities and users' satisfaction, and then the second priority to be made on the information/communication integration, container logistics integration and supporting activities in sequence. Next, they can clarify priorities on individual PPI for stakeholder management. This may help port managers and policy makers to converge the different objectives and concerns, accordingly to draw managerial and operational implications for stakeholder management.

However, this study has some limitations and future research areas are suggested accordingly. First, even though this study attempted to address the weaknesses of the traditional IPA method and its empirical applications, the predictive validation problem remains questioned, which is a major problem of IPA study that employed the direct importance for analysis (Azzopardi and Nash, 2013). To this end, a longitudinal research needs to be implemented for investigating the situation of ports within different timeframes. Second, the relative importance of PPIs was obtained using AHP with ten experts of knowledge and experience related to the leading container ports in Asia. Future studies using fuzzy AHP to deal with uncertainty in data and involving a wider selection of experts from different regions would strengthen the results' validity. Third, this study can be extended to incorporate a plausible IPA method based on flexible data-centred diagonal line model (e.g. Lai and Hitchcock, 2015) to realise more flexible decision making which can reflect dynamic planning and strategic setting with reference to market situations and resource availability. Last, this is a sort of a static analysis using both primary data and secondary data, which may be possible to make it dynamic analysis. Further longitudinal studies highly demand to look at the dynamic impact of the stakeholders' management on port performance in future within different timeframes.

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