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How port community systems can contribute to port competitiveness : developing a costbenefit framework

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How port community systems can contribute to port competitiveness: developing a cost-benefit framework

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Abstract

The trend towards collaborative innovation in the maritime supply chain implies a good understanding of the actors and their roles, and an efficient exchange of information. A Port Community System (PCS) increases port efficiency by connecting the ICT systems of each of its members, thereby facilitating their communication. To verify whether this type of collaboration and its benefits actually materialize, an understanding of the costs and benefits of such PCS is required. This paper recognizes the inconsistency in the existing literature with respect to PCS costs and benefits quantification. Therefore, after an in-depth literature review, interviews with experts of PCS were carried out, a comprehensive framework to quantify the costs and benefits was developed. Next, a case study was drawn-up to develop a discussion regarding the costs and the extra benefits that port stakeholders incur when using a module of a PCS. The case analysis suggests that there is a positive cost-benefit balance for every stakeholder adhering to a PCS. By covering the development and operational costs of certain modules, PCS operators seek to increase the port competitiveness. This way, PCS users manage to gain higher net benefits and have a competitive advantage over other port stakeholders outside the community.

Keywords

Port community system; PCS; maritime supply chain; cost and benefit framework

1. Introduction

The trend towards collaborative innovation (also called co.innovation) in the maritime supply chain implies a good understanding of the actors and their roles, and an efficient exchange of information with the different stakeholders. Case analysis of 75 port-related innovation initiatives (Sys et al., 2015) allows mapping the efforts that the maritime and port sector makes to prepare itself for future trends. One conclusion is that in port-related innovation, there is often a positive benefit-cost balance for every stakeholder, however, the benefit is often not yet seen, and therefore the willingness to pay is usually very low. This innovation sample shows that 40% (29) of the cases are oriented towards the enhancement of the information flow throughout the maritime supply chain.

Enabled by the possibilities by newly developed technology, ICT developments are more and more present in business processes. This type of business innovation is now seen as a game changer. Analysing the services provided by the ports and maritime sector, the same types of

developments are also pursued there. Van de Voorde and Vanelslander (2014) state that co-operation is a trend in the development of the future maritime supply chains. In extension, port community systems (PCS), as dedicated maritime ICT platforms, are further developed to enhance the co-operation between players that take part in the same maritime supply chains (MSC) within a certain area.

The review of the relevant literature shows that PCS have attracted the attention of researchers (see Appendix). However, few have tackled the issue of implementing a PCS in the context of port and port stakeholders' competitiveness. At the same time, port competitiveness has not often been studied from the angle of ICT. De Martino and Morvillo (2008) did so and reviewed the activities, resources and inter-organizational relationships that most commonly have an impact on port competitiveness. Customer satisfaction and port competitiveness are used as independent variables by Lee et al. (2015) when studying the influence of the e-Transformation of container port management systems. The latest technological advancements in port business show that ICT is a further pillar that has a main impact on port competitiveness next to costs, geographical location and services (Meersman et al., 2010). The enhanced sharing of information between port stakeholders regarding cargo, the preannouncement of vessel/vehicle arrival at ports/terminals or the secure electronic transfer of official documents are only a few examples of functionalities provided by PCS that bring a competitive advantage.

PCS initiators or the later users should ideally perform a cost-benefit analysis and apply a consistent framework to support their decision of developing/adhering to this type of collaboration and create a more competitive position. The purpose of this paper is to question the influencing role of PCS on port actors' competitiveness in general and maritime stakeholders in particular. The latter is done by identifying the costs and benefits encountered by different MSC stakeholders from implementing or integrating pre-existing systems into an electronic platform connecting multiple actors making up a port community. To that purpose, a comprehensive framework is developed to identify the costs and benefits that each actor faces by setting or keeping up a PCS. The later in-depth view on a specific case illustrates the application and functionality of the framework.

The paper is organised as follows. Section 2 presents a review of specific aspects of PCS developments, not only in seaports, but also in airports, so as to find best practices to learn from for the seaport sector. Furthermore, an overview is given of scientific studies analysing PCS. Section 3 presents the typical architecture of PCS functions and application modules. In Section 4, the costs and benefits brought by setting up and joining collaborative PCS platforms are detailed from the perspective of the port-related stakeholders, and a view is

given on whether a PCS contributes to port stakeholders' competitiveness. Section 5 focuses on the Antwerp Port Community System (APCS) case study and presents the costs and benefits that apply to each stakeholder when joining a specific implemented application. It shows to what extent the APCS administrator encourages the use of PCS and gives a competitive advantage to the community as a whole. Finally, section 6 draws conclusions and provides recommendations for future research for this specific topic.

2. Community systems: a literature review

Most major seaports and airports have implemented some kind of community system. The next section firstly clarifies the understanding and role of community systems in seaports, followed by a brief comparison with airport community systems. For each of those, the operator is first defined. Secondly, the literature over the 2000-2015 period is reviewed to identify both cost and benefit elements of a PCS.

2.1. Community systems in ports

The European Port Community System Association (2011) defines a PCS as a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the efficiency and competitive positions of the seaport communities. A Port Community System optimizes, manages and automates logistics-efficient processes through a single submission of data, connecting transport and logistics chains.

Literature review shows that the definitions of these systems have evolved together with the scope of PCS from connecting multiple communication systems (Rodon and Ramis-Pujol, 2006) and serving as information hub (Srouf et al., 2008) to being used as a tool that facilitate the exchange of information regarding commercial or administrative matters so as to generate value added and offer new logistics value propositions (PORTEL, 2009). However, the main objective of a PCS remains to encourage the co-operation amongst logistics stakeholders and to increase their competitiveness as a community. This co-operation is based on the integration of communication procedures both within the same maritime supply chain (vertical integration) and across supply chains (horizontal integration) (De Borger and De Bruyne, 2011). Van de Voorde & Vanelslander (2014) define the term 'vertical integration' as collaboration between logistics service providers at a different level within a specific supply-chain. Studies referring to horizontal collaboration between logistics players (for example Cruijssen et al., 2007; Leitner et al., 2011) focused on partnerships for freight consolidation matters or sharing the same infrastructure capacity. PCS facilitate both types of integration.

1 In line with such integration, Keceli (2011) proposes a three-stage strategy for implementing a
2 PCS. Firstly, he suggests integrating port operators and port authority (harbour master). Next,
3 other ICT systems of other authorities or service providers (e.g. customs, pilotage) should be
4 integrated. Finally, value-added services - can be commercialized. By formulating this
5 strategy, Keceli (2011) suggests that such collaboration platforms have a higher commercial
6 success when used by port service providers.
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10 The most frequent reasons for developing PCS are the following ones.
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- 12 - To optimise the flows of information (efficiency and effectiveness) (van Oosterhout et
13 al, 2007; Mila, 2007; Gustafsson, 2007; Duran and Cordova, 2012; Keceli, 2011).
- 14 - To allow for better control the import/export activity by customs services (Keceli et al,
15 2008; Aydogdu and Aksoy, 2015).
- 16 - To generate more competitive advantage for the port (Cuadro and Cervera, 2004; van
17 Oosterhout et al, 2007; Cordova and Duran, 2014).
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24 Port actors are known to have various relationships: some collaborate, while others compete.
25 All are under the subordination of authorities like customs or port authorities, so they follow
26 specific procedures. Port-related stakeholders are currently users of PCS. Undertaking their
27 activity in a port environment, they have to comply with a specific sequence of operations for
28 freight and information flows. When developing a PCS, best practices and already
29 implemented community systems are often taken as examples from other sectors (e.g. air
30 transport) or from other ports.
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33 A PCS, when implemented, becomes part of the port management scheme. Heaver et al.
34 (2001) note that the managerial actions of a port authority are ultimately derived from its
35 basic objectives, which are influenced by its ownership, structure and mandate. The port
36 management scheme and the port organization type influence the objective of each PCS and
37 consequently the type of benefits they are creating. Verhoeven (2010) argues that the port
38 management is the responsibility of the port authorities. He identifies three types of port
39 authority functions: landlord, regulator and operator function. Meersman et al. (2011) identify
40 four types of port organization: service port, tool port, landlord port and fully privatized port.
41 Hence, these managerial structures are later used to investigate the functional orientation of
42 PCS.
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56 **2.2.Community systems in airports**

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58 In parallel to the maritime transport sector, the air transport sector also introduced airport
59 community systems (often known as ACS, cargo community systems or CCS). Similar to a
60 PCS, an ACS serves as an information exchange platform between the operators and
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1 authorities operating at an airport. UNECE (2012) understands an ACS as “a neutral and open
2 electronic platform enabling intelligent and secure information exchange between public and
3 private stakeholders in order to improve the competitive position of airport communities”. In
4 comparison with early PCS, airports have developed only recently such platforms, but they
5 seem to feature a shorter implementation period. The development of collaboration platforms
6 with the air communities is facilitated by the already implemented standards. UNECE (2012)
7 notices that most airport community systems have their own internal standards, but they
8 communicate with other such systems or trade communities using international air-specific
9 standards, in particular IATA standards for EDI and for XML. The services offered by the
10 ACS are often the same as those offered by PCS. Therefore, the types of benefits gained by
11 the corresponding stakeholders involved in both types of systems are assumed to be similar.
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13 The main difference between the establishment of community systems in the air transport
14 sector and in the seaport sector, is the presence of specific IATA communication standards for
15 the air sector. In the maritime sector, each stakeholder has individually developed its own
16 type of communication platform with its customers to increase its efficiency (in terms of
17 reduced costs, less errors and faster turnaround). Given their diversity and difficulty to
18 integrate, these pre-existing systems are now seen as the main hurdle that hampers the way
19 forward for implementation of most PCS. This obviously has repercussions on their benefit.
20 Hence, an in-depth understanding of the costs and benefits of such community system is
21 required, so as to show for the various actors the net gain that can be obtained by using a joint
22 platform with common standards of data exchange.
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24 **2.3.Approaches and findings in literature on PCS analysis**

25 Literature with respect to PCS focuses mainly on the actual implementation. The literature
26 review in this section focuses on the used methods to study the collaboration platforms in
27 general and the associated costs and benefits of implementation in particular. A detailed
28 overview is presented in the Appendix.
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Table **1** summarises the main findings of the literature review.

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Table 1. Approaches used with respect to PCS developments.

Approaches	Time block	Number of references	References referring to PCS benefits	References referring to PCS costs
Descriptive approach	1994-2015	19	16	4
Conducting interviews and expert meetings	2005-2011	7	7	2
Development of indicators for measuring PCS efficiency	2012-2014	2	2	1
Quantitative approach	2011-2015	3	3	0

Source: own composition

From table 1, it is clear that the majority of the studies adopt a descriptive approach. A second group of reviewed articles had a more empirical orientation when describing a specific PCS. These studies opted for interviews or expert meetings as part of their methodological approach in order to define the relations established within PCS or to reveal issues encountered when integrating pre-existing systems. Thirdly, only two studies have been conducted to define indicators to measure the strategic and operational efficiency of PCS (Cordova and Duran, 2012, 2014). Lastly, a limited number of studies used quantitative data to assess the features implemented by PCS's. These studies have used the fuzzy TOPSIS technique (Ghazanfari, Rouhani and Jafari, 2014) respectively scenario-based models (Tijan, Agatić and Hlača, 2012; Aydogdu and Aksou, 2015) to study the benefits of PCS. The orientation of the reviewed studies is more focused on identifying and describing the benefits of PCS. Therefore, the costs are weakly studied. This is a gap to the state-of-the-art in literature that this paper will fill to some extent.

Authors like Keceli (2011) or Aydogdu and Aksoy (2015) focused their studies on PCS benefits. Nonetheless, difficulties in finding common ground to assess the impact of PCS on port competitiveness still exist. These difficulties are mostly encountered because of each PCS's unique architecture and purpose. This paper also intends shedding further light on this.

Ultimately, the literature review reveals that there is a wide range of PCS setups and each has its own characteristics and types of costs and benefits. The next section focuses on the PCS design and functionalities, so as to create a typology which can be subject to cost and benefit analysis in section 4 subsequently.

3. PCS design and functionalities

Srour et al. (2008) make a categorization of typical PCS architectures. The same authors also focus on identifying the particularities of the context and the steps that contributed to the development of PCS in ten ports, creating a collection of success factors for PCS

implementation. Rodon and Ramis-Pujol (2006) study the PCS created within Spanish ports and address the issues of integrating pre-existing systems in one central communication platform. They conclude that the companies in the port sector did not need to integrate. Duran and Cordova (2012) make a conceptual analysis and develop a set of indicators that allow evaluating the knowledge management of the main actors participating in the community. Next, a study developed by Global Institute of Logistics (2012) gathers in a single report different aspects that characterize PCS as individual platforms that cannot be compared. They also note that in each PCS setting, the Port Authority is the natural leader of the created community.

Although there is a wide range of studies describing the PCS architecture, only few authors (van Oosterhout et al., 2007; Aydogdu and Aksou, 2015) referred to PCS functionalities or to specific applications developed within PCS (also known as PCS modules). PCS are individual platforms that incorporate different functionalities of one specific port. Furthermore, these functionalities are being supported by applications of different modules that deal with more specific tasks. A PCS has therefore a multi-layer structure characterized by different functionalities that are put into practice through a set of separate modules. The stakeholders involved in the port activity (whether private stakeholders, customs or port authorities) can either use the entire range of functionalities of a PCS, or only a part of them, as well as use information available through individual PCS modules.

Figure 1 depicts the multi-layer structure of a PCS.

Figure 1. Multi-layer structure of PCS functions and modules.

Subsequently, the following two sections will describe the PCS functionalities and application modules.

3.1.PCS functionalities

Keceli (2011) notes that the functionalities and services offered by already implemented PCS are always under development. Furthermore, the range of - actors involved in a PCS is wide, containing both public agencies (like customs, port authorities or other local authorities) and private operators (e.g. shipping lines, stevedores, terminal operators, inland transport operators or forwarders).

The functionalities of already developed PCS platforms are covering areas like logistics, customs clearance, navigation and dangerous goods declaration (Figure 1). The logistics function provides electronic communication for efficient management of the entire logistics chain, from hinterland transport to the connection to maritime transport and beyond, without impairing the private nature of commercially sensitive data. The navigation function through PCS guarantees an efficient approach for smooth and safe traffic and optimum planning during arrival and departure. It usually includes requests for services, port infrastructure usage and administrative handling. The dangerous goods declaration functionality uses electronic communication to guarantee an efficient data flow for the declaration of the transport of hazardous cargo and the related obligations. Finally, the customs clearance function simplifies the import and export control procedures and offers better control of the administrative process. This results in shorter customs clearance times and easy access to information, reducing the dwell time of cargo.

The functionalities covered by each PCS are not always the same. Keceli (2011) lists the functionalities of five ports and concludes that the scope of each PCS is influenced by its major stakeholders. In line with Keceli (2011),

Table 2 presents a more detailed overview for an extra 8 ports. With the additional ports, this study offers a perspective of ports within areas like Western- and Southern-Europe, Asia and the US. Each of these ports has a fairly long tradition in operating PCS and had them implemented before the 2008 economic crisis. In addition to what Keceli (2011) included, this overview incorporates the ports' organization typology as defined by Meersman et al. (2011), it points out the year of implementation of each system and it upgrades the lists of functionalities by adding the dangerous cargo declaration as a new PCS function.

Table 2. PCS key Functions.

Country	Port	Port Community platform	Year of implementation	Function			
				Logistics	Navigation	Dangerous cargo declaration	Customs
Landlord ports							
Germany	Bremen	BHT (former DBH)	1980s	X		X	X
	Hamburg	CCS Dakosy	1983	X	X	X	X
Belgium	Antwerp	SEAGHA	1986		X		X
		APCS	2012	X	X	X	X
Spain	Barcelona	PORTIC	1999	X		X	X
	Valencia	INTTRA	2006	X		X	
USA	Los Angeles and Long Beach	eModal	1999	X			
The Netherlands	Amsterdam	PortNET	2000	X			
		Portbase	2009	X	X	X	X
	Rotterdam	Port infolink	2002	X	X		
		Portbase	2009	X	X	X	X
South Korea	Busan	PORT-MIS	2004		X		
		KTNET	2006				X
Limited service port							
France	Le Havre	SOGET	1983	X			X
Service ports							
UK	Felixstowe	MCP	1984	X		X	X
Singapore	Singapore	Portnet	1984	X	X	X	X
		TradeXchange	2007	X			X
China	Hong Kong	Tradelink	1988	X			X
		OnePort	2003	X	X		X
		KTNET	2006				X

Source: own compilation based on Keceli (2011)

From

Table 2, it is first of all clear that each PCS has different functionalities, and furthermore also that the types of charges and benefits gained through each functionality are different. Furthermore, due to this diversity and the involvement of many stakeholders, the evaluation of the aggregated PCS costs and benefits is difficult to conduct.

The second finding refers to the longevity of the PCS. Only a limited amount of old platforms (for instance the ports of Hamburg or Singapore) cover the full range of functionalities, while others (for instance Hong Kong, Bremen or Le Havre) offer still a limited set. Nonetheless, within the latter ports, parallel IT systems apart from PCS have been developed to cover the extra functions.

Another interesting observation is that the more recently implemented PCS were preceded by other similar collaboration platforms within the same port (APCS at the port of Antwerp, Portbase at the ports of Rotterdam and Amsterdam or OnePort at the port of Hong Kong), and incorporate more functionalities than the older versions. These examples make a clear point that the implementation of a PCS is a continuous expansion process.

Finally, the studied sample of PCS suggests that the most frequently applied functionalities by communities are those related to logistics applications and customs-related activity. This finding emerges regardless the type of port management structure.

3.2.The modular approach of PCS

The services provided through each PCS function are available by using several modules (applications). For example, the pre-notification delivery/collection of a container at the terminals is done through a module of the logistics function, while a ‘customs declaration’ is submitted through a module belonging to the customs clearance function. This approach, initiated in the CCS Dakosy system in Hamburg (1983), the Portnet system in Singapore (1984), and the SEAGHA (1986) system in Antwerp was adopted by later developed PCS. Furthermore, more recent systems such as the Port Infolink system at the Port of Rotterdam and APCS at the port of Antwerp have also been successful in using a modular implementation approach, which may refer to a next generation of PCS that is getting implemented.

A modular approach contributes largely to the successful implementation of a PCS. The advantage of this approach is that the information flow destined for different purposes is processed through different applications. This way, each module connects together only the stakeholders that are interested in sending/receiving one specific type of information. The specific relations that are being created through individual modules determine the types of cost and benefits supported by each port community system user.

The identification of the various types of costs and benefits is exactly the subject of the next section.

4. Developing a PCS costs and benefits framework

With PCS defined and their functionalities delineated as in previous sections, the current section focuses on defining the costs and benefits of port-related stakeholders that are using or implementing a PCS as a communication platform. A conceptual overview of costs and benefits of PCS is presented in table 3 respectively 4.

This overview shows that there is not an overall consensus regarding a specific set of elements that are to be considered costs and benefits of PCS. Moreover, a widely agreed set of cost and benefit elements linked with the development or integration through PCS has not yet been proposed.

Furthermore, little attention was paid to identifying the types of costs or benefits that each type of PCS user experiences after joining such a platform, which would allow further quantification. The framework developed in this section has the aim of filling this gap.

4.1.Costs of PCS

The challenges that need to be overcome when developing a PCS are various. Developing a PCS is costly, requires long time and effort and needs to find solutions for the needs of all actors that have their activity in a port (Tsamboulas and Ballis, 2013). Table 3 presents the most cited types of costs that are associated with PCS developments.

Table 3. PCS costs per stakeholder.

	Cost elements	Source
PCS operator (administrator)	Platform development costs (including hardware/software acquisition/development cost, staff cost, training etc.)	Miranda, 2003; Sweeney and Evangelista, 2006
	Operating cost (staff cost, maintenance cost, storage and data management costs)	Tijan, 2009
PCS user (MSC stakeholders)	Connection cost	Morton and Rook, 2015
	Hardware/software acquisition/development cost	Miranda, 2003; Morton and Rook, 2015
	Training cost	Srouf et al., 2008
	Transaction fees (license fees)	van Baalen and Beije, 1998; Southon et al., 1999; Morton and Rook, 2015

Source: own composition.

Table 3 firstly shows that the costs that are usually encountered by PCS users are weakly analysed (see also

Table 1). The range of studies which are analysing the PCS are focusing more on the benefits rather than the costs. Yet, both costs and benefits are equally important when a port-related company is willing to develop or integrate in its operational structure such a system.

Secondly, a clear distinction was made between the costs incurred by the PCS operator (administrator) and by the other users. Sweeney and Evangelista (2006) refer to this first category of costs incurred by PCS operators as general ICT implementation costs, seen also as one-time costs. Miranda (2003) notes that if an investment makes good sense in the long-term, but it ends up also being beneficial to others, including competitors, it will not be seen as feasible by the private sector, since it would imply free-riding behaviour. In this situation, the role of government or of a neutral authority is crucial in developing and providing the initial capital. Moreover, the system developer or administrator often incurs the operating costs of PCS.

As for the second category, Miranda (2003) considers that the PCS users defined as stakeholders adhering to a PCS, have fixed operating costs, namely the purchase of the hardware equipment and the cost of a secured connection. His statement is later on completed by Tijan (2009) who adds that PCS implies costs for information storage and data governance. The latter are ultimately formulated as PCS transactions fees (licence fees) that can be either fixed or variable. Moreover, Tijan et al.(2012) agree that the cost of PCS implementation and maintenance must follow a sharing scheme agreed by its developers and customers.

The private stakeholders in ports are the direct beneficiaries of PCS. Nevertheless, these stakeholders are not willing to make important investments into initiatives that depend also on external parties' involvement. De la Guia (2013) states that during the implementation of a PCS, the main challenge is to create a "spirit of co-operation" among the different partners involved in the project. This spirit of co-operation leads later on to benefits for each community partner. A further example of barriers met when integrating port stakeholders into a wider PCS is the difficulty to merge communication platforms that were initially developed on an individual basis (Kerkhof, 2014).

4.2.Benefits of PCS

Next to the identification of the costs, the literature review allows concluding that the use of a PCS provides a wide range of benefits. **Error! Reference source not found.** gives a detailed overview of the most cited PCS benefits to be considered when adhering to a PCS collaboration platform. The benefits definition and quantification methods were adopted from literature that studied the benefits of PCS and were adjusted with the help of interviews. The methods addressing quantification of PCS benefits mostly refer to identifying time and labour

1 saved for obtaining, verifying or correcting certain information, determining the difference in
2 cost of previous means of communication compared to current ones and summing up the
3 revenues from fees or increased productivity.

4 As shown in Table 4, PCS benefits can be divided into two broad categories, namely the
5 digital economy and the community attendance benefits. The digital economy benefits are
6 understood as the benefits of the universal use of IT (hardware, software, applications and
7 telecommunication) in all aspects of the economy, including internal operations of
8 organizations (business, government and non-profit); transactions between organizations; and
9 transactions between individuals on the one hand, acting both as consumers and citizens, and
10 organizations on the other hand (Atkinson and McKay, 2007).
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Table 4. PCS benefits and their proposed evaluation method

	Benefit	Definition	Quantification method
1. Digital economy benefits			
1.1. Economic benefits	Reduced access cost to information	The concerned companies can access information in a more efficient way. Less paper work and labour consumed to find specific data. (Miranda, 2003; Čišić et al., 2009; Keceli, 2011; Tsamboulas, Moraiti and Lekka, 2012; Aydogdu and Aksoy, 2015)	Value of time and labour saved
	Reduced cost of communication	Companies can send information in a more efficient way. Less paper work and labour consumed to find specific data. (Keceli, 2011; Aydogdu and Aksoy, 2015)	Difference with cost of previous forms of communication
	Less illegal transactions	The temptation of corruption is eliminated through using PCS. Automated systems will ensure fair transactions between all the stakeholders involved in the community. (Keceli, 2011; Aydogdu and Aksoy, 2015)	Percentage of illegal transaction reduction, estimation of prejudice
1.2. Increased quality of information	Decreased rate of errors	Errors due to the human factor and their consequences are being eliminated. (Diaz, 2003; Srour et al., 2008; Keceli, 2011)	Time and labour consumed to correct the errors
	Reduced rate of data inconsistency	Automatic exchange of data from/to the central PCS database ensures a reliable set of information.	Time and labour consumed to manually verify data
1.3. Increased performance	Fast access to information	The time to access a specific kind of information is less, thanks to the implementation of electronic platforms. (Aydogdu and Aksoy, 2015)	Measurement of the increase of activity (for instance same amount of employees but tripled activity volume), increase in revenue
	Efficient use of resources	The stakeholders' infrastructure is being used in a more efficient way. (Wrigley, Wagenaar and Clarke, 1994; Mila, 2007; Tijan, Agatić and Hlača, 2012; Keceli, 2011)	Increase in capacity usage of equipment (infrastructure)
2. Community attendance benefits			
2.1. Increased efficiency (user level)	Access to real time information (one time stop shop)	No matter their sequence in the supply chain, stakeholders are better informed about their incoming tasks. (Keceli, 2011; Tsamboulas and Ballis, 2013)	Savings in cost of accessing certain information
	Higher value-added services	Collaboration is easier to be established between the members of the community. (Compes, Lopez and Poole, 1998; Srour et al., 2008)	Revenue from added value services through PCS
2.2. Increased connectivity	Compliance with community standards and regulations	Standardized messages and data are better structured for the use of all interested actors. (Long, 2009)	Less investment needed for business growth

4.2.1. Digital economy benefits

Most PCS have different applications that have integrated electronic data interchange (EDI) modules; those benefits are considered under the digital economy category. Obara et al. (2010) note that the application of electronic data (and document) interchange can produce the following advantages: faster and more efficient information exchange, reduced lead time, lower costs by reducing paperwork, reduced number of errors, better sharing and tracking of data and higher inventory turnovers. Moreover, Aydogdu and Aksoy (2015) indicate that PCS have indirect economic benefits such as: decreased cost of information access, decreased communication costs, extra income for government agencies (i.e. through fees), correct taxation, prevention of smuggling, prevention of illegal income (i.e. bribery), and decreased foreign dependency on port and logistics software.

4.2.2. Community attendance benefits

Port stakeholders being involved in PCS have extra benefits gained from being involved in a community network. From this perspective, the critical need is to achieve an understanding between the different parties in the port community. Each port stakeholder has divergent roles and different interests, whereby they need to agree on the procedures to be followed by all for the benefit of the overall port performance (Diaz, 2003). Within a PCS, the information is entered into the system only once and is accessible by each participant that is granted access to that information. Therefore, working with different companies becomes much easier as they all share common front-to-end structured information and business rules. In terms of visibility, having a PCS in place drastically reduces the opaqueness of the port as the information which is crucial for each individual actor's operation, can also be valued by others (Gustafsson, 2007). Cruijsen et al. (2007) identify three categories of opportunities that the co-operating logistics service providers can enjoy when being integrated in a community. These propositions are related to cost and productivity, service (greater customer value added) and market position.

4.2.3. Benefits of PCS according to each type of port stakeholder

The benefits of PCS developments, from a port stakeholder point of view, are often associated with both development of IT platforms and merger to a community. From a stakeholder's perspective, the former category of benefits is more predictable and easily quantifiable. This can be done by evaluating the difference in communication expenditures made before and after the implementation of the supposed IT platform. The benefits brought by community

1 integration are more difficult to estimate. The former overlaps with the benefits put forward
2 by OECD (2012) as digital economy benefits and it refers to the upgrade of communication to
3 IT. The latter are more dependent on the other stakeholders' actions. On the contrary, the
4 most important pre-condition for the long-term materialisation of PCS benefits is achieving a
5 critical mass of participants. Srour et al. (2008) note that the more parties are involved, the
6 more and accurately information can be processed within the community, the higher the rate
7 of re-use of information, the more and the higher-quality information services can be provided
8 to the participants.

14 4.2.3.1. General benefits for all PCS users

17 A detailed calculation of the amounts of time and costs saved by the use of electronic
18 documents transfer in port-related transactions proves the effectiveness of PCS
19 implementation. Čišić et al. (2009) demonstrate that the labour price, time and cost of
20 document processing for the application of e-documents could be a very significant source of
21 savings and can lead to the accumulation of funds for investments. For instance, in 2008, the
22 monetary savings obtained by the use of e-documents (compared to traditional, paper-based
23 documents) can amount to 38.79%: the average cost of an e-document is \$4.52 (compared to
24 \$7.39 for a paper document). Time savings achieved by using the e-document amount to
25 39.64%. Electronic communication can result in savings of up to 39% in the document flow
26 and will affect the profitability of the entire port community (Čišić et al. 2009).

36 4.2.3.2. Benefits for Port Authorities

38 The implementation of the PCS will provide benefits for the port authority in all of its
39 activities. Port authorities will be able to easier co-ordinate the port activities, better supervise
40 the activities of port operators, better control the port operations, and enjoy a setup of a time-
41 dependent and accurate database for decision making and development of strategic plans
42 (Tijan et al, 2012).

48 4.2.3.3. Benefits for customs

50 Another aspect of PCS benefits is presented from the perspective of the port of Valencia. In
51 this specific PCS setting, the customs police receives the list of goods at the same time as
52 terminal operators, and that list is automatically cross-checked against the authorizations from
53 customs declarations through a link with Spanish Custom's central system, all paperless. As a
54 result, it only takes three minutes to check a list of 5,000 movements, compared to four hours
55 before the PCS was implemented (De la Guia, 2013).

4.2.3.4. Benefits for stevedores and terminal operators

The main benefits gained by (maritime and inland) terminal operators after installing PCS are directly linked with the planning of terminal operations. Important gains are seen from lower turnaround times and exact estimation of required labour and handling equipment at the terminal. For example, the electronic processing of container data and the vessels' stowage plans increases the efficiency of the loading and discharge orders. Nevertheless, PCS information allows terminal operators to quickly follow up the containers or cargo along the supply chains, thereby decreasing the chances for errors.

4.2.3.5. Benefits for freight forwarders and maritime agents

Poletan-Jugovic (2009) states that the forwarders and maritime agents who are dealing with numerous documents and are interacting with other port stakeholders in arranging import or export transactions, will gain significant advantages through PCS implementation. The benefits gained by this category of port stakeholders are: faster and better work organization, reduction of transaction expenses (expenses of finding potential business partners, negotiation expenses, contracting, agreement protection, expenses of contract induction, expenses that occur if the contract does not run as planned, expenses regarding conflicts and disputes during the contract materialization, and, finally, reduced service expenses). The advantages gained by the forwarders and maritime agents are reflected in the entire operation process in the seaport as a community.

4.2.3.6. Benefits for pre- and on-carriage (road, rail, inland waterway operators)

By using the PCS platform, road transport operators may benefit from less turnaround time at the terminals, increased transparency of the duration of handlings and better planning of their activities by avoiding queuing at the terminals. Modules of the logistics functionality (e.g. 'container release', 'booking of transport orders', etc.) allow road operators to pick their transport orders according to their available capacity (or to perform a combination of tasks) in order to reduce their cost of empty trips or to gain new income. The administrative work done by the road carriers is optimized by having standard documents pass through an automatic crosschecking system at the delivered/pick-up moment at the terminals.

For the rail as well as barge operators, joining a PCS results in a more transparent view of the duration and scheduled time of handling operation, less turnaround time, better organization of the process and precise information regarding the estimation of the infrastructure capacity. Inland waterway operators, after registering to a PCS platform, can create planning requests

to the (maritime and inland) terminals through a single registration platform (Aydogdu and Aksoy, 2015). For barge operators, a useful additional feature of PCS is showing the transparency of the terminal schedule and the sailing constraints in and around a port. Information regarding the port physical infrastructure (e.g. lock planning) is also available. This allows barge operators to better plan their activity and estimate the time of arrival/departure at/from every terminal. Real-time information is used also by barge operators to optimize their speed for less fuel consumption (Port of Antwerp, 2015).

4.2.3.7. Benefits for importers/exporters (customs brokers)

Import/exporters connected via a PCS benefit from a more reliable, accurate and transparent source of information. Most of the modules dedicated to the use of this type of operators are part of the customs functionality. Their main advantages of linking up with a PCS are related to simplification of customs processes and automatic sending of the customs clearance reports. The information given by/to importers/exporters is automatically cross-checked to match existing references in the PCS database (De la Guia, 2013).

4.2.3.8. Benefits for shippers

By using a PCS application, the shippers do not have to enter data manually regarding their consignment in order to book a maritime transport. This way, less mistakes are made due to human errors, so labour costs for solving these errors are saved (Keceli, 2011). The data that is used for these types of operators comes from reusing the booking information of transport orders and shipping instructions.

4.2.4. PCS cost and benefits framework

The detailed analysis of the PCS costs and benefits results in the development of a conceptual framework. This framework allows evaluating the effectiveness of a PCS. As it was described in the previous sections, the MSC stakeholders as PCS users incur different types of costs and benefits. Table 5 shows these for different PCS users when using the services of a PCS.

Table 5. PCS cost-benefit framework.

		PCS operator	Port community system users										
			Port Authority Customs Shipping line	Shipping agent	Freight forwarder	Customs declarant Stevedore	Terminal operator	Road, rail and inland waterways transport operator	Harbour master, pilotage etc.	Others (e.g. Police, sanitary and veterinary authorities etc.)			
COSTS	Development and administration												
	Platform development	x											
	Operating and maintenance costs	x											
	Join-in												
	Connection cost		x	x	x	x	x	x	x	x	x	x	
	Hardware/software investment costs		x	x	x	x	x	x	x	x	x	x	
	Training cost		x	x	x	x	x	x	x	x	x	x	
Transactions fees (license fees)				x	x	x	x	x	x	x	x	x	
BENEFITS	Digital economy benefits												
	Reduced cost for information access			x	x	x	x	x	x	x	x	x	x
	Reduced cost of communication			x	x	x	x	x	x	x	x	x	x
	Less illegal transactions			x	x			x					
	Decreased rate of errors			x	x	x	x	x	x	x	x	x	x
	Reduced rate of data inconsistency			x	x	x	x	x	x	x	x	x	x
	Fast access to information			x	x	x	x	x	x	x	x	x	x
	Efficient use of resources			x	x	x	x	x	x	x	x	x	x
	Community attendance benefits												
	Access to real time information			x	x	x	x	x	x	x	x	x	x
	Higher value-added services			x	x	x	x	x	x	x	x	x	x
Compliance with standards and regulations			x	x	x	x	x	x	x	x	x	x	

The perspectives of both the costs (developer or join-in users) and the benefits (from attending a digital platform and being involved in an information network community) are captured in the current framework for evaluating the PCS costs and benefits.

The PCS operator, by subcontracting software developers, is usually the developer and administrator of the PCS, and therefore is the one who encounters most of this category of costs. PCS access fees, requested by the PCS operator, through the port authority, have mainly the purpose to cover the development and maintenance expenses.

1 Practical experience has shown that port actors had developed under individual means their
2 own IT systems to optimize their activity. Nonetheless, there are still users for which
3 connecting to a PCS means digitalizing part of their activity and therefore gaining advantages
4 from this perspective. Late developments of PCS have tried to integrate previously in-house
5 built information management systems into the community platform. Therefore, open access
6 to the community information system brings all its advantages also from this point of view.
7 The latter subcategory of benefits are enjoyed by all the PCS users.

13 Although the costs and benefits incurred by PCS users are similar in typology, the actual
14 values of costs and benefits might differ. Therefore, the balance between costs and benefits
15 regarding the adherence to PCS should be evaluated from each stakeholder's perspective.
16 From this point of view, if the costs of joining a PCS are higher than the benefits, the private
17 operators have no willingness to pay and the collaboration stops. An equitable balance
18 between the costs and benefits brought by the attendance of each stakeholder to a PCS is
19 difficult to determine. Hence, a careful evaluation must be carried out.

26 This framework has the goal of shedding light on the costs and benefits that each MSC
27 stakeholder encounters when adhering to a PCS. A further step in coming research is to use
28 this framework as a quantification tool. This way, companies with low willingness to pay for
29 attending community information platforms can have a better view on the types of costs and
30 benefits such can have. Nonetheless, this framework also comes in the help of PCS
31 administrators (port authorities) in having a clear view on the types of costs and benefits each
32 PCS user encounters and benefit from already developed theory.

39 The next section will illustrate the developed framework for the port of Antwerp PCS.

42 **5. Application of the framework: APCS case study**

44 The APCS was initiated with the opening of the e-Desk platform in 2012. It hosts four main
45 functionalities, namely cargo & logistics, navigation, customs and dangerous goods
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Table 2). The development of APCS followed a bottom-up approach. This means that a central authority did not impose the development of this communication platform, but it was created starting from the needs of the port stakeholders. More specifically, stakeholders, that had already developed their own digital applications, felt the need of being integrated with their collaborators through a larger communication platform. Moreover, the main aspects that contributed to the development of APCS were the navigation and customs services. These two services represented the root from which the logistics functionality has been extended later on. The extra functionality related to the hazardous goods declaration was developed under impulse of European legislation (Port of Antwerp, 2015).

5.1.APCS functionalities

The stakeholders present in the port of Antwerp can benefit from a wide range of applications by joining the APCS. APCS started by addressing to the stakeholders that were operating containerized cargo and later, its service was addressed also to break-bulk operators. More than half of the modules which are functional under APCS are open for the use of ships' agents (57%) and shipping lines (52%) (Figure 2). Freight forwarders can benefit from 45% of the modules and terminal operators enjoy 41% of the modules. Finally, 30% of the applications are open for the use of the port authority.

Figure 2. Percentage of APCS applications dedicated to the use of each stakeholder

Source: own composition based on Port of Antwerp (2015)

The establishment of APCS features a wide range of benefits. Moreover, a fixed value cannot be indicated as the total benefit of using of the system. Due to the complexity and the number of involved stakeholders, the direct economic efficiency of the PCS is difficult to determine.

1 The current approach proposes that the costs and benefits of one module at each individual
2 stakeholder level should be evaluated.

3 4 **5.2.ECS: arrival notice of export cargo at terminals - costs and benefits**

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6 The module analysed here is the Export Control System (ECS) implemented as a customs
7 clearance functionality within APCS. This was the first module implemented by the new
8 APCS ownership, Alfaport and the Antwerp Port Authority, in 2012. ECS is part of the *E-*
9 *Customs* initiative to be implemented at European community level (EC, 2005). In the port of
10 Antwerp, this was adopted under the name of *ECS: arrival notice of export cargo*. This
11 module's aim is to enhance the customs control for export cargo by using a pre-notification
12 system. In other words, it allows customs declarants to notify the terminal operator about the
13 upcoming cargo and to pass on export declaration details electronically.

14
15 An analysis of the costs and benefits encountered by the users of the ECS module is
16 conducted by applying the framework developed for PCS cost and benefits evaluation in
17 section 4. The ECS module of APCS is an example of both vertical and horizontal
18 collaboration of actors active in the maritime supply chain. ECS's development phases are
19 included in Vanelslander et al. (2015), who analyse the conditions under which port-related
20 innovation initiatives achieve their success. The latter study points out that the strong
21 involvement of terminal operators in building the communication infrastructure throughout all
22 the development stages of ECS was a critical condition for its success. More specifically, this
23 module was initially developed as a private initiative and had the purpose of vertically
24 optimizing the operations that required PSA Antwerp's involvement. At that stage, the
25 development cost of the communication platform was supported by the terminal operator.
26 Furthermore, the direct beneficiaries of this data communication platform, besides the
27 terminal operator, are the freight forwarders and the local customs authority. Later on,
28 APCS's goal was that all the container terminals in the port would use it. In order to do so, the
29 PSA application was upgraded and integrated in the current customs functionality of the
30 APCS. Currently, the costs of this deployment are fully covered by the port authority,
31 including operational costs and the establishment of new connections. This step means that
32 the ECS module will integrate also at a horizontal level port stakeholders like terminal
33 operators or freight forwarders.

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35 Currently, the ECS module is dedicated to the use of the following port stakeholders: terminal
36 operators, freight forwarders and customs authority. While the application is accessible by all
37 freight forwarders that are using the port of Antwerp as a shipping point, not all the terminals

joined this module. Initially developed for the use of export declarations of containerized cargo, this module has been extended also to break-bulk cargo. Several RO-RO-dedicated terminals are currently using the ECS module of APCS. This expansion serves as an example of horizontal collaboration between parallel supply chains through sharing best practices. The benefits brought by this module are different for each type of stakeholder. Table 6 shows which stakeholders involved in the ECS module of APCS incur which type of costs and benefits.

Table 6. Costs and benefits of port stakeholders that are using the ECS module of APCS.

		PCS operator		ECS module user		
		Port association	IT developer	Customs	Freight forwarders	Terminal operator
COSTS	Development and administration					
	Platform development		x			
	Operating and maintenance costs	x				
	Join-in					
	Hardware/software investment costs					
	Training cost					
	Operating cost					
	Fees for information use					
BENEFITS	Digital economy benefits					
	Reduced cost for information access			x	x	x
	Reduced cost of communication			x	x	x
	Revenue (from fees)					
	Less illegal transactions			x		
	Decreased rate of errors			x	x	x
	Eliminate the rate of data inconsistency			x	x	x
	Fast access to information			x	x	x
	Efficient use of resources			x		x
	Community attendance benefits					
	Increased access to information			x	x	x
	Higher value-added services					
	Compliance with standards and regulations			x	x	x

Source: own compilation based on interview with Kerkhof (2015)

1 In sum, the ECS module development evolution shows that the collaboration within the
2 maritime supply chain through the PCS implementation has made positive progress. As stated
3 by Miranda (2003), a neutral authority had to take action for the implementation of IT
4 communication platforms. The neutral authority, in this case, has the goal of increasing the
5 competitiveness of the entire community. Current users of the ECS module (terminal
6 operators, freight forwarders and customs authorities) do not incur any extra additional cost
7 by using the ECS module of APCS. The implementation and operational costs are fully
8 covered by the port authority. Consequently, the PCS users, by using the ECS module, enjoy
9 both digital economy and community types of benefits. Moreover, the access to these benefits
10 is not hindered by financial capabilities. Therefore, in this case, the PCS operator supports the
11 development and implementation of a new form of port stakeholder collaboration that
12 facilitates their communication operations, gaining new benefits and increasing their
13 competitiveness as a community.

14 Some of the costs and benefits (e.g. fees for information use, revenue etc.) listed in the PCS
15 evaluation framework are not applicable for evaluation in the current case study. This proves
16 than, due the fact that each PCS module has its own setting (for instance dedicated only to
17 part of the stakeholders, not offering a full range of functionalities) the related costs and
18 benefits are also different. Nevertheless, the developed framework is a useful tool to create a
19 first inventory of the cost and benefits of adhering to one PCS module as a necessary step
20 before quantification.

21 **6. Conclusions, Scholarly Contribution and Managerial Implications**

22 The communication means between stakeholders of the maritime supply chain have evolved.
23 More specifically, ICT systems have a core role in the daily activities of shipping industry.
24 This paper develops a cost-benefit quantitation framework for port PCS systems. The aim of
25 the paper is twofold. First, the aggregated costs and benefits of implementing a new PCS are
26 listed. Secondly, the costs and benefits from a stakeholder perspective of using the PCS
27 modules are identified. Moreover, it answers the question how the PCS operator makes efforts
28 to increase the competitive advantage of the community.

29 To achieve these objectives, an in-depth desk research was conducted, Furthermore, by
30 conducting interviews and participating in expert meetings on the theme of PCS, details
31 regarding the issues encountered by both PCS operators and users were investigated. This
32 approach has shown that despite the overall consensus regarding the goals of this type of
33 collaboration, a comprehensive framework for quantifying the costs and benefits of PCS is

1 still lacking. The following paragraphs summarize how the current research is both beneficial
2 to scholarly knowledge and to support the maritime sector's managerial decisions.
3

4 With regards to scholarly knowledge, this study shows that the functionalities and the design
5 of each PCS are the main elements that determine the range of costs and benefits incurred by
6 port operators. Furthermore, the costs and benefits determined by PCS should be evaluated at
7 module level. Through this perspective, the benefits of joining a PCS can be divided in two
8 categories. The first category refers to benefits brought by the digitalization of administrative
9 procedures (for instance minimizing document processing time, faster exchange of
10 information, reduced number of errors due to single data entry, minimized cost of documents
11 transfer or increased information accuracy). The second category refers to the benefits to the
12 PCS users of being part of a community (for instance increased market position or increased
13 competitiveness).
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22 The most cited reasons in favour of PCS developments are to reduce the cost of
23 communication through digitalization and to increase the level of competitiveness for its
24 users. The development of a PCS does not anticipate a certain level of benefits for its users; it
25 is rather the role of the joint community to maximize the potential benefits of using such
26 collaboration platform. In this regard, the undertaken example has shown that the efforts of
27 the PCS operator (the port authority) by covering the development and further expansion
28 costs is aiming to bring new benefits for PCS users. This way, terminal operators, freight
29 forwarders or customs declarants, by using a more comprehensive tool to conduct their
30 communication obligation with respect to customs procedures, may enjoy an increase in their
31 competitiveness.
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41 Regarding managerial implication, this study offers a cohesive view regarding the costs and
42 benefits that each MSC stakeholder has after joining a certain module. Therefore, it proposes
43 a more structured framework of evaluating the costs and benefits of a PCS from each MSC
44 stakeholder point of view, allowing each of them to decide on joining the platform or not, and
45 on enjoying the benefits from increased competitiveness . It is useful also for port
46 administrators which need to take action for the implementation of PCS. It raises the
47 awareness of MSC stakeholders regarding the complete set of costs and benefits that are
48 brought forward by a PCS.
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57 Future research on the identification of aggregated PCS costs and benefits is still possible. A
58 full cost-benefit analysis can be pursued and evaluate the effectiveness of joining one module
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or another of a previously developed port collaboration platform. A possible analysis can also be done from the point of view of one stakeholder that joins multiple PCS modules and this way, an assessment of the added value of being involved in additional modules can be carried out.

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1 Appendix. Overview of the literature focused on analysing PCS developments

Author	Year	Title	Purpose of study	Studied ports	Benefits of PCS (findings)	Cost of PCS (findings)
STUDIES THAT ADOPTED A DESCRIPTIVE APPROACH						
Wrigley, Wagenaar and Clarke	1994	Electronic data interchange in international trade: frameworks for the strategic analysis of ocean port communities	This paper develops two frameworks to assess the level and nature of electronic trade integration within the context of a port community enterprise model.	No specific port mentioned	Improves time operations; resource consumption; and improves control.	No direct reference to PCS cost
Lopez and Poole	1998	Quality assurance in the maritime port logistics chain: the case of Valencia, Spain	It explore the concept of quality in relation to port services, and discuss certification of service providers as a means of signalling quality to their customers.	Port of Valencia	High quality port services punctuality, quality, reliability and price.	No direct reference to PCS cost
Diaz	2003	Port Community System: A Key Component of the Future Vision for Cargo and Port Security	It gives a general overview of PCS	No specific port mentioned	Prevents errors and dramatically reduces paperwork. It makes the port more efficient and easier to work with. Working with different companies is easy because they all share a common “front-end” to send and receive structured information and business rules; data quality and overall “port procedures” are enforced and followed by all participants.	No direct reference to PCS cost
Cuadro Erasquet and Cervera	2004	Benchmarking the port services: a customer-oriented proposal	This paper aims to adapt the benchmarking technique to the sphere of ports. Compares the activity of a port with that of its competitors, which is considered to be excellent.	Port of Valencia	PCS offers a competitive advantage	No direct reference to PCS cost
Miranda	2003	Preliminary analysis of APEC	It seeks to identify and discuss some of the factors that influence the success of port communities that have already implemented collaborative Information and Communication Technology (ICT) solutions and how these factors can be applied to other ports intending to adopt similar systems	No specific port	PCS users have longer term benefits of lower costs, better profitability and revenue.	PCS have fixed operating costs. These costs include the purchase of hardware or internet connections.
Nam-Kyu and Hyung Rim	2005	Port Information System For Port Authority	It aims to define its relationship through a study on the port types of advanced countries and their information systems	Busan Port Authority	Benefits not mentioned	No direct reference to PCS cost
Cullinane, Yim Yap and Lam	2007	The port of Singapore and its governance structure	This paper studies the governance structure of PCS in Singapore	Singapore	Port community provides world-class and competitive products and service standards.	No direct reference to PCS cost

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Author	Year	Title	Purpose of study	Studied ports	Benefits of PCS (findings)	Cost of PCS (findings)
van Oosterhout et al.	2007	Visibility Platforms for Enhancing Supply Chain Security: a Case Study in the Port of Rotterdam	It maps the information needs onto the current IT architecture and IT systems in the port of Rotterdam.	Rotterdam	PCS brings competitive advantages	No direct reference to PCS cost
Strour, van Oosterhout, van Baalen, Zuidwijk	2008	PSC Implementation: Lessons Learned from an International Scan	They document lessons learned within each life cycle stage as derived from an international scan of PCS deployments	10 ports (kept anonymous)	Lower maintenance costs and low difficulties in extending and expanding with new services and communication channels	High initial investment cost and usually the users have to support the later on operational cost.
Aksentijević, Tijan and Hlača	2009	Importance of organizational information security in PCS	IT outlines information security principles that should be accounted for during creation of port community systems.	No specific port mentioned	Support to port operations, efficient cost control, easy change management, disaster recovery, business continuity and integration into existing business blueprints of all included port function concession holders and other participants.	No PCS costs mentioned
Brooks, McCalla, Pallis and Van Der Lugt	2010	Coordination and cooperation in strategic port management: the case of Atlantic Canada's ports	It fundaments the lesson that Canadian ports might learn from others engaged in cooperative activities or increasing competitiveness through coordination along the supply chain.	Atlantic Canadian ports	PCS address solving congestion and landside hinterland access problems.	No direct reference to PCS cost
Long	2009	Port community system	This article traces the history of a port community system from the early days of planning through to the current day, in order to provide insight into the benefits that can be achieved by both Government and the trade, transport and logistics communities.	Felixstowe Port Community System	Ports offering PCS are easier to use and therefore, more attractive to existing and potential users. Beneficial effects are distinguished for all members of the port community.	No direct reference to PCS cost
Tijan, Kos and Ogrizovic	2009	Disaster recovery and business continuity in port community systems	It emphasise the importance of information security within the PCS, presenting a firm base for the introduction of both the concept and the model of integral security.	No study case	Lowers the risk; offers potential processes and services.	The cost of PCS implementation and maintenance must follow a sharing scheme agreed by its developers and customers.
Tijan	2009	Data classification and information lifecycle management in port community systems	It identifies possible key issues during the DC/ILM system implementation and finally proposes suggested implementation paths in order to overcome operational difficulties	No specific port	Benefits not mentioned	PCS might incur cost for information storage and data governance.
Wortelboer-van Donselaar and Kolkman	2010	Societal costs and benefits of cooperation between port authorities	It shows how, cooperation between port authorities can contribute to our societal welfare and what role the national government can play in promoting this cooperation.	Dutch ports	Social benefits as a result of cooperation between seaport authorities.	No direct reference to PCS cost

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Author	Year	Title	Purpose of study	Studied ports	Benefits of PCS (findings)	Cost of PCS (findings)
Tsamboulas, Moraiti and Lekka	2012	Performance Evaluation for Implementation of PCS	This paper proposes a methodology to evaluate port performance changes with the introduction of PCS, which, under a competitive environment is of significant importance to port management.	Ports are kept anonymous	The core benefits are higher operational efficiency and speed regarding port processes, increased productivity, reduction of costs, and improved customer service and customer relations.	No PCS costs mentioned
Tsamboulas and Ballis	2013	Port community systems: requirements, functionalities and implementation complications	Presents the specific Adriatic port community characteristics regarding its users requirements, functionalities and ways to overcome complications in the implementation of Port Community Systems	No specific port	PCS offers increased accessibility to information for all actors	No PCS costs mentioned
Çiğjan	2014	Seaport cluster information systems — A foundation for Port Community Systems' architecture	The author presents the main characteristics of existing seaport cluster information systems, their possible overlapping dependencies and initial component analysis, as a basis for decision-making related to architecture of future PCS	No specific port mentioned	Benefits not mentioned	No specific PCS costs mentioned
van der Horst and van der Lugt	2015	Coordination mechanisms in improving hinterland accessibility:	IT gains a better understanding on coordination in hinterland chains	Port of Rotterdam	Increase operational coordination, and horizontal coordination.	No specific PCS costs mentioned
STUDIES THAT USED INTERVIEWS OR EXPERT MEETINGS AS METHODOLOGICAL APPROACH						
Park, Chioi, Lee, Kang and Yang	2005	Port management information system towards privatization	It defines PCS relationships through a study on the port types of advanced countries and their information systems	Busan, Hamburg, PACE of London, Singapore, Hong Kong.	It provides a general list of advantages and problems of each system	No PCS costs mentioned
Sweeney and Evangelista	2006	Port Community Learning Needs: Analysis and Design	It describes the learning needs analysis conducted amongst key port community actors in three ports.	Irish port communities (ports not mentioned)	Value adding to ports and its evolving environment; brings awareness of the practical business benefits that can be achieved through an electronic community information service	PCS has general ICT implementation costs
Rodon and Ramis-Pujol	2006	Exploring the Intricacies of Integrating with a PCS	The research addresses the issue of integration of pre-existing systems	Spanish port community	Companies are more integrated with the PCS.	No direct reference to PCS cost
Mila	2007	Information Technologies in ports: Port Community Systems	Its purpose is to identify the main features of the Port Community Systems (PCS)	IAPH member ports	Optimizations of goods flows and information flows.	No direct reference to PCS cost
Gustafsson	2007	Interaction between transport, infrastructure, and institutional management - Case study of a port community system	It suggests that the interaction between the domains of transport, infrastructure, and institutional management through PCS is a step forward.	Port of Gothenburg, Sweden	Information in PCS is crucial to each individual actor's operation but also can be of value to others.	No direct reference to PCS cost

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Author	Year	Title	Purpose of study	Studied ports	Benefits of PCS (findings)	Cost of PCS (findings)
Keceli, Choi.; Cha and Aydogdu	2008	A Study on Adoption of PCS According to Organization Size	It develops a model for determining the factors affecting PCS and to find out the factors affecting the user acceptance of port community systems	Busan Port region	PCS is a tool for port and customs-related document submission.	The cost of system use is less important than the reliability of the system and the compatibility of its functions.
Keceli	2011	A proposed innovation strategy for Turkish port administration policy via information technology	This paper aims to develop a guideline for successful development of a port community system in Turkey on the basis of SWOT analysis of the current situation.	Turkish ports (no specific port mentioned)	Information quality, economic benefits, international competitiveness. Efficiency of terminal operations.	No direct reference to PCS cost
STUDIES FOCUSED ON DEVELOPMENT OF INDICATORS FOR MEASURING THE EFFICIENCY OF A PCS						
Duran and Cordova	2012	Conceptual Analysis for the Strategic and Operational Knowledge Management of a Port Community	Develops a set of indicators oriented toward measuring the knowledge management of the main actors participating in the community.	No case study	It increases port efficiency and effectiveness through generate knowledge.	No direct reference to PCS cost
Cordova and Duran	2014	A Business Model Design for the Strategic and Operational Knowledge Management of a Port Community	This work proposes a business model design for managing a seaport community	No specific port mentioned	A port gains competitive advantages if PCS is implemented	High investment cost for PCS development. Operational cost is supported by the port authorities or service rendering companies.
STUDIES FOCUSED ON APPLYING A QUANTITATIVE METHODOLOGY						
Tijan, Agatić and Hlača	2012	The necessity of PCS implementation in the Croatian seaports	The authors define the Port Community and analyse the basic features of seaport clusters and Port Community Members	Croatian ports	PCS enhances the: <ul style="list-style-type: none"> – allocation of resources – continuous data update, – development of operational plans within schedules, and – rapid action during emergency situations. 	No direct reference to PCS cost
Ghazanfari, Rouhani and Jafari	2014	A fuzzy TOPSIS model to evaluate the Business Intelligence competencies of Port Community Systems	It proposes a new model which provides a simple approach to the assessment of the BI competencies of port community systems in organization.	No specific port mentioned	Benefits not mentioned	No specific PCS costs mentioned
Aydogdu and Aksoy	2015	A study on quantitative benefits of port community systems	This study aims to develop a simulation model to capture the differences between conventional port logistics business and a conceptual model where a hypothetical PCS is in place.	Turkish port industry	Less processes are repeated indirect economic benefits, such as decreased cost of information access, decreased communication costs for shipping companies, extra income for government (i.e. through user fees), correct taxation, prevention of smuggling, prevention of illegal income.	No direct reference to PCS cost