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Abstract Port Community Systems have become a staple technological platform used to exchange information between the public and private agents and entities involved in ship and cargo services within seaports. In this paper, the theoretical background of the Port Community System is provided, emphasizing the importance of its implementation, and stakeholder collaboration. Different models of introducing an integrated Port Community System in seaports are analysed using literature review and actual cases in some of the most prominent seaports.

Keywords: port community system, seaport stakeholders, business models, seaport stakeholder collaboration

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1 Introduction

Seaports, defined as a geographical location where cargo changes its transport mode (one of these being a seagoing vessel), are important drivers of the regional economy (Hintjens, Hassel, Vanelslander, & Voorde, 2020). The seaport's competitiveness depends not only on exceptional geographical position, related to closeness of important markets and connection to seaport hinterland, but also on cost, efficiency, reliability, accessibility, safety, as well as quality of various services it offers, including transportation services, auxiliary services and added value logistic services. Seaports have to continuously improve their operations, both commercial and administrative in order to stay competitive (Tijan, Jović, & Karanikić, 2019).

Numerous seaports have already designed and implemented the Port Community System (PCS). PCS allows the users to make service requests and input their information directly into the port's information system (Keceli, 2011), and enables the intelligent and protected exchange of information between involved public and private port users (Simoni, Schiavone, Risitano, Leone, & Chen, 2020). The higher the level of collaboration and integration between the port and supply chain stakeholders, the greater the sustainability of both the overall supply chain and the port (Tijan, Agatić, Jović, & Aksentijević, 2019). Seaport stakeholders have their own distinctive interests, which may minimize the ability to incorporate the PCS into seaport operations. Nonetheless, numerous seaports have recognized the benefits that PCS brings, and are utilizing it to assist with everyday operations.

There is no universal approach to PCS introduction and exploitation, or a universal applicable business model, due to the heterogenous nature of global seaports and their management. Furthermore, the majority of research in this area is focused on digitalization of processes and unification of underlying procedures and document flow, and not on relevant PCS introduction and exploitation models. By working not only on the theoretical aspects of PCS systems, but also in their envisaging and implementation, the authors have identified the lack of applicable knowledge in this area and therefore wanted to verify the pragmatic and empiric findings by cross checking them using scientific resources. To overcome this research gap, the authors have conducted the review of available literature and sources. The goal of the research is to analyze the various PCS business models, given the existence of various stakeholders who have their own particular interests and preferences. Given

the fact that the transparency and easy access to data are the basis for successful transport business, the research problem stems from unnecessary costs and lost time due to the outdated business procedures and inadequate execution and monitoring of business processes in transport, which can largely be remedied by introducing a PCS. This paper presents a review of research papers and other sources (such as official webpages of seaports, seaport stakeholders and maritime transport enterprises), ultimately providing a better understanding of PCS business models.

2 Theoretical background

Port Community System is the technological platform that enables networking between the public and private agents and entities involved in the ship and cargo services offered by ports (Caldeirinha, Felício, Salvador, Nabais, & Pinho, 2020), through a single point of data entry (Aloini, Benevento, Stefanini, & Zerbino, 2020).

Two main values are co-created by the interrelated organizations operating within a PCS: the movement of goods and human beings and enforcing the law, public order, and safety. (Nota, Bisogno & Saccomanno, 2018). Generally accepted guidelines for development of a Port Community System require that PCS is formed by the community for the community and that the community are, in general, shareholders of the PCS Operator. (European Port Community Systems Association, 2011) However, in real PCS scenarios, in many cases, the community are not participants or owners of the PCS Operator, instead, it is often mandated by the governmental body (for example, port authorities) or maintains a mixed management and ownership structure. This presents one of the major issues in PCS building and operations and makes it difficult for PCS to facilitate smooth flow of electronic data and reduce inefficiencies in port business processes. Therefore, the selection of a proper operating model is crucial for the success of every PCS project. While individual business information systems that relate to individual stakeholders process and store only data and messages that are relevant for them, PCS can exchange data that is useful for a wider number of users (Tijan, Aksentijević, & Čišić, 2014). PCS exists in a dynamic network consisting of a significant number of stakeholders (as shown in Figure 1 with different business processes, technologies and roles (Bezić, Tijan, & Aksentijević, 2011).

Figure 1: Port community system and involved stakeholders
Source: (Tijan, Kos, & Ogrizović, 2009)

PCS is largely based on a strong collaboration between all the involved public and private organizations (Baron & Mathieu, 2013), establishing a link between different types of technologies, processes, people, and standards (Rodon & Ramis-Pujol, 2006). Regional or even global PCSs might be designed (Jović, Tijan, Žgaljić, & Karanikić, 2020), helping to enhance the overall PCS performance in both local and foreign trade activities (Moros-Daza, Amaya-Mier, Garcia-Llinas, & Voß, 2019). In both cases a further standardization of interfaces and processes would be required. The requirements of and benefits for each company would have to be outlined and agreed on in advance (Treppte, 2011).

Bringing all users together, PCS enhances the efficiency of the physical flow of freight, drives economic growth, and as a secondary result, assists in reducing externalities such as pollution, congestion, and land use impacts (Irannezhad, Hickman, & Prato, 2017). According to (Zerbino, Aloini, Dulmin, & Mininno,

2019), one of the reasons for PCS development is the possibility to reduce the average time frame of port procedures, and to enhance information exchange, consequently improving overall port competitiveness.

Going beyond traditional function of PCS to share information, a PCS can offer modules to support a variety of activities (Baalen, Zuidwijk, & Nunen, 2009). The recent versions of PCS include the cloud services, which is becoming a significant factor in the historical development of information technology outsourcing (Johansson & Muhic, 2017).

Although a PCS connects multiple systems operated by a variety of organizations that make up a seaport community (IPCSA, 2020), it should be noted that for each port region, a PCS can take different forms in response to various physical, modal, jurisdictional, and operational characteristics (Tsamboulas, Moraiti, & Lekka, 2012). PCS functions may be divided into three categories: port management functions (documents provided to port authorities or terminal operators), customs functions (documents needed for customs clearance) and online platforms for electronic commerce between port users (Keceli, 2011).

3 Methodology

The literature review was conducted in order to research the theoretical foundations of models of port community systems. The authors opted to perform the search using only resources in English language and started with the inclusion criteria by using a combination of keyword "Port Community System models" and "Port Community System" (title, abstract and keywords). Web of Science, Google Scholar, ResearchGate databases were mainly used for this purpose. Due to the previously identified lack of the research dealing on this topic, the search for articles was not limited to a specific period, and mostly includes journal articles and conference papers. To ensure that possible useful findings from various fields were not excluded, the authors did not limit the queries to a specific field or index. Furthermore, due to aforementioned lack of research dealing with PCS models, the PCS models are further analysed by means of several real-life implementations such as: Port of Hamburg, The Port Authority of Valencia, Port of Rotterdam, The Antwerp PCS, etc. Using described methodology, a total of 36 resources have been

identified and used in the description of development and exploitation models of a PCS that follows.

4 Development and exploitation models of a Port Community System

Seaport stakeholders have their own preferences, which can decrease the willingness of certain members of the port community to incorporate PCS. The PCS should therefore enable the promotion of autonomy of all participants and at the same time include and support activities in various business processes in relation to seaports. In this respect, such a system does not only deal with internal needs of each individual company, but also with needs of other seaport stakeholders. In particular, the port authority attempts (or should attempt) to optimize the impact of the seaport's activities on the territory in terms of value added (local employment and incomes); on the other hand, the port operators should attempt to maximize the value for the final customer (De Martino, Errichiello, Marasco, & Morvillo, 2013).

Depending on a type of stakeholder's organization and its objectives, ownership model can be private, public or mixed public-private (PPP) (Marek, 2017). If the ownership model is of a private kind, the so-called bottom-up approach would be implemented in the system implementation. In this way, it is expected that the stakeholders (shipping companies, shipping agents, brokers, etc...) will support the work with the PCS since it is accepted by the operators themselves. Ports such as port of Singapore, Hamburg, Felixstowe belong to that kind of PCS model. For example, the Port Community System for the Port of Hamburg is operated by DAKOSY, one of the leading platform and software providers for logistics (IPCSA, 2021a). The PCS connects all stakeholders involved in cargo handling to perform fast, efficient and largely-automated processes in seaports and enables integrated intermodal hinterland handling of all modes of transport (Dakosy, 2021).

The top-down approach would be implemented if the ownership model is more similar to the public style, with a focus on port authorities and public bodies as the key stakeholders who determine the speed of implementation and set targets in the development of the PCS system (Marek, 2017). Ports such as Port of Valencia, Port of Rotterdam and Amsterdam belong to public PCS model.

The port authority plays an important role in implementing and creating the port development strategy and in coordinating the port community as a whole (João, Batista, Ayala Botto, & Cordón Lagares, 2018). The port authority is responsible for secure, sustainable and competitive port growth and may be a key factor in the implementation of the PCS (Tijan, Agatić, & Hlača, 2012). The implementation of the PCS may allow port authorities to coordinate port activities, monitor the activities of port operators and control port operations more easily (Carlan, Sys, & Vanelslander, 2016). For example, via Valenciaport PCS, the Port Authority of Valencia offers e-commerce solutions that make it easier for goods to move through the ports of Valencia, Sagunto and Gandía, adding a clearly perceptible value to the consumers and port users ("Port Authority of Valencia," 2021).

(Chandra & Hillegersberg, 2017) have conducted a Port of Rotterdam case study in which the importance of cooperation between port authorities and other stakeholders involved in the implementation of the PCS is visible. According to the study (Chandra & Hillegersberg, 2017), due to dissatisfaction with the Port of Rotterdam's information system, Port Infolink B.V. was established in 2002 (as a separated governance entity). Initiated by the Port of Rotterdam Authority, the pre-partnership cooperation process started by defining the most important issues that hinders the efficient flow of goods through the port. The Port Authority was the sole owner of Port Infolink, meaning that it was responsible for the initial investment in the development of the information system. This initiative included other stakeholders in the partnership program delivery phase (e.g. Customs). In early 2009, the next governance life cycle was marked by the merger of Port Infolink in Rotterdam and PortNET in Amsterdam, which provided the Ports of Rotterdam and Amsterdam with a single PCS (Chandra & Hillegersberg, 2017).

PPP is, in essence, a mixture of the two previously described ownership models. The aim of this ownership model is either to achieve complete acceptance of the PCS system or active role of private corporations in implementing the PCS system through a top-down approach (Marek, 2017). According to (Klievink, 2015), in *public-private collaboration* PCS design, data are handed over to the PCS but are still owned by the individual actors submitting the data. This allows government to access the data and allows the PCS to optimize port operations by enabling companies operating in the port data sharing without losing control. Ports such as Port of Barcelona and Antwerp belong to this type of PCS model. PORTIC is the

Port Community System operator in Barcelona and a private-public partnership between the Port Community of Barcelona, Port Authority of Barcelona, Financial Institutions (La Caixa, Banc Sabadell) and the Chamber of Commerce of Barcelona (IPCSA, 2021b). The Antwerp PCS is a cooperation between Antwerp Port Authority and Alfaport Antwerpen -Federation of Port Companies and Logistic Service Providers - private IT-sector (Descartes – Porthus) (Waterschoot, n.d.).
(Mendes Constante, 2019), outlines the features of business models based on combinations of PCS ownership and operational models. In the scenario where both the PCS ownership and the operational model are private, active engagement by the public sector is required in order to successfully implement complete integration and interoperability between all stakeholders involved. In the scenario where the PCS ownership is public but the operating model is private, private company operates the PCS on a commercial basis whereas public bodies play a crucial role in ensuring that services are provided fairly and neutrally to all stakeholders involved (Mendes Constante, 2019).

To summarize, the above points to the fact that when it comes to PCS business objectives, the main goal is to add value and improve the quality of port operations, logistics and the transport chain while at the same time reducing operating costs. It is also important to remember that during development it is extremely important to take care of the selection of PCS model because it will determine the specific financial model and goals that PCS as a project aspires to.

5 Discussion and conclusion

Seaports, as complex systems, are of vital importance for global trade activities because the most important international transport corridors and cargo flows pass through them and dictate global trends of economic development.

Daily port operations highly depend on information technologies and information systems. They have become irreplaceable elements in numerous seaports where they play an important role in port's overall business success. Information and communication systems such as PCS have become the staple technical ingredients used in optimal flow of information and provision of quality and efficient transport service and flexible and efficient functioning of port system as an important link in the transport chain.

Collaboration between stakeholders is a very important factor that enhances port system functioning. Utilizing coordination with other systems and technologies, they form an entity that significantly affects port system operations efficiency and coordination. Familiar expression stating that the chain is only as strong as its weakest link is certainly applicable to this concept too. If a port is recognizable on the global market, it attracts the largest ships and therefore the largest companies in international shipping industry. On the other hand, if the service it provides is not at an equally high level, or it is provided in a way that stakeholders offering port services are not interconnected and harmonized, the whole chain, including the port itself leave an impression of inconsistency.

The ownership and control over the PCS system are often overlooked parameters during the PCS inception phase. A PCS is a constantly developing system that needs to reflect every change in the port's environment, underlying technology, business processes, legal framework and all stakeholders. As it requires a significant coordination effort for proper functioning, it is very important to involve all stakeholders to provide a meaningful input to this process, reserve proper funding and ensure stakeholders' collaboration in order to achieve the goal of PCS's introduction.

The limitation of this research is primarily the fact that only English resources were used. PCS systems are adopted world-wide, and it is possible that the research base would be wider if other languages were included too, but that would lead the research outside of the applicable scope and format. Furthermore, PCS implementation is a highly operative endeavour, and many lessons learned are not published in a form of a scientific research, and therefore they cannot be used. Primary research hypothesis was confirmed, as not many quality resources are dealing with the selection of PCS model being a crucial factor in its successful implementation. Most researches are focused to project implementation phases, project management and encompassing all processes as success factors, but take PCS business model as something that is predetermined and not questioned. Additional authors' finding is that the selection of a proper PCS business model is a prerequisite for its successful implementation and operation, as only the appropriate PCS model can guarantee resource savings typically tied to PCS, as opposed to manual administrative processing or disjointed and heterogeneous port IT systems.

The implementation of a PCS helps improve the efficiency in communication among port community members, avoids duplicate data entry, optimizes flow and timely exchange of information, and increases protection from unauthorized access. It should enable electronic business operations which should result in a more efficient service, better mutual coordination, decrease in operative expenses and, finally, a more competitive port. Leading international seaports have recognized the importance and advantages of modern technologies in providing high quality services in ports.

The research can have many potential new venues and possibilities. PCS systems in the future will have to be highly flexible and interconnected, especially with introduction and absorption of novel technologies like Internet of Things, entire information platforms being delivered using cloud approach, active and passive tags and globally recognized cargo ledgers with distributed and transparent proof of authenticity. Integration of all these technologies will be a challenge for all PCS operators and provide new possibilities for research as those models that are successful now might not be suitable. One realistic possibility of a future research in this area might be analysis of impact of new information technologies on selected PCS business models.

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