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Group-specific business process improvements via a port community system: the case of Rotterdam

Michele Simoni[a], Francesco Schiavone[a,b], Marcello Risitano[a], Daniele Leone[a] and Junsong Chen[b]

[a]Department of Management Studies and Quantitative Methods, Parthenope University of Naples, Napoli, Italy; [b]Emlyon Business School, Ecully, France

ABSTRACT
The Port Community System is a type of digital platform that offers several benefits and improvements to the operations and supply chain of an increasing number of ports worldwide. However, prior literature does not explain in detail how these various types of benefits and business process improvements spread within a port and are obtained by its main groups of stakeholders (agents, terminal operators, and so on). The article fills this literature gap by analysing the distribution of benefits and improvements among the main types of port actors in Rotterdam (the Netherlands) after the introduction of the 'Portbase' platform. The results show that PCS effectively improves port stakeholders' business processes only if the platform is the core element of a port digital transformation strategy, and if it offers a large portfolio of smart IT solutions that (a) directly improve the system quality, information quality and service quality, and (b) are properly targeted for the business processes that are carried out by the different groups of port stakeholders.

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Business process improvement; digital platforms; Port Community System; port management; port stakeholders

1. Introduction

Business process improvement (BPI) is fundamental for maintaining high organisational competitiveness over time (Hung 2006). Information technology (IT) is a crucial element that enables organisations to achieve BPI and make their operations and supply chains more efficient (Davenport and Short 1990; Adesola and Baines 2005; Rosemann and Vom Brocke 2015). In recent years, the ongoing digital transformation occurring in many industries has offered remarkable technology-based opportunities for the improvement of business processes (Gölzer and Fritzsche 2017; Vial 2019; Saragiotis 2019). Among the various technological options, a dominant role has been played by digital platforms (Nylén and Holmström 2015; Fatorachian and Kazemi 2018; Frank, Dalenogare, and Ayala 2019), which grant firms access to a shared information system (IS) by simultaneously addressing and integrating the interdependent processes of the various platform adopters.

In the maritime industry, the Port Community System (PCS) is a relevant type of digital platform that offers several net benefits to port users (Long 2009). A PCS can be defined as a 'holistic, geographically bounded information hub that primarily serves the interest of a heterogeneous collective of port-related companies' (Srour et al. 2008). The PCS acts, therefore, as an information-sharing platform for all the stakeholders of a port ecosystem. Despite the growing attention paid by scholars and practitioners to PCS, there are still various gaps in empirical research regarding the BPI achieved via this type of platform, such as the exploitation of PCS data (Saragiotis 2019). In particular, ports are logistical and operational ecosystems in which a large and heterogeneous set of stakeholders interact and implement a variety of articulated and interconnected business operations and processes (Parola, Satta, and Caschili 2014). Such heterogeneity of the port stakeholders is likely to lead to heterogeneous set benefits and process improvements for each category of PCS end-users.

Most of the literature about PCS (e.g. Aydogdu and Aksoy 2015; Long 2009; Carlan, Sys, and Vanelslander 2016; Di Vaio and Varriale 2020) has generally reviewed the main benefits offered by the platform to port authorities (PAs) and the other port stakeholders, without analysing in detail: (a) the various classes of improvements offered by this platform for its various groups of end-users; and (b) which conditions allow these groups of users to benefit from the platform. This lack of theoretical knowledge generates various critical industrial problems, and makes the formulation and implementation of a suitable and well-targeted strategy of digital transformation, centred around a PCS, more complex for PAs. To this end, it is highly important to gain an in-depth understanding of which conditions (e.g. quality of information or quality of service) are more crucial in providing some specific net benefits to particular groups of port stakeholders. Real-world evidence and information about these issues could, for instance, support PAs in selecting better PCS hardware and software components and their complementary elements, as well as enabling them to better promote the platform as a

CONTACT Francesco Schiavone francesco.schiavone@uniparthenope.it Department of Management Studies and Quantitative Methods, Parthenope University of Naples, Napoli 80132, Italy

crucial value proposition for some specific groups of port stakeholders (public or private).

The present article contributes to the extant literature pertaining to PCS (Aydogdu and Aksoy 2015; Carlan, Sys, and Vanelslander 2016; Saragiotis 2019; Di Vaio and Varriale 2020) by exploring in detail the various types of benefits and BPIs achieved by each main group of port stakeholders (agents, terminal operators, and so on) through using this digital platform. The research question of the article is: How do the various key groups of port stakeholders gain group-specific BPIs via a Port Community System? To answer this question, the article offers an analysis of the distribution of benefits and BPIs gained by the main types of port actors in Rotterdam (the Netherlands) after the introduction of the 'Portbase' platform. The results show that users' BPIs obtained via PCS are stronger when the platform is a core element of a broader digital transformation strategy, and when port management pays great attention to the quality dimensions that are perceived and prioritised by various key groups of port stakeholders.

The article is organised as follows: after the introduction, Section 2 reports the theoretical background of the study and develops some theoretical propositions. Section 3 describes the research method used to perform the case study reported in Section 4. Section 5 shows the results giving insights and interpretations on each analysed process. Section 6 discusses the results and summarises the research and managerial implications of the study. The last section reports the main conclusions of the study.

2. Theoretical background

2.1. The digital technology-driven improvement of business processes

Business process management (BPM) refers to the 'achievement of an organization's objectives through the improvement, management and control of essential business processes' (Jeston and Nelis 2008, 11). This definition stresses the key function of business process improvement (BPI) for effective BPM. BPI refers to 'a methodology that is designed to bring about step-function improvements in administrative and support processes using approaches such as process benchmarking, process redesign and process re-engineering' (Harrington, Esseling, and Van Nimwegen 1997). In practice, improving processes means to map, analyse and redesign the sequence of steps forming the existing process (Stevenson and Sum 2015). Such improvement, if performed via information systems, should lead the firm to achieve some operational, managerial, strategic, technological and/or organisational benefits (Shang and Seddon 2002). The sustained benefits gained by the organisation should thus be the final (and positive) outcomes of its effective efforts in continuous improvement and BPM (Trkman 2010). Process improvement entails a set of critical skills and capabilities by which organisations manage and implement various core elements of BPM, such as strategic alignment, methods and IT (Rosemann and Vom Brocke 2015). The applications of the most typical methods for process improvement, such as benchmarking, six sigma, lean management and total quality management, and the process breakthrough methodology (Harrington 1995), show that the meanings and dimensions of improvement can be several, broad and multifaceted. Thus, different companies with different improvement goals are very likely to design and implement different improvement models (Jeston and Nelis 2008). Improvement differs from the re-engineering of the business process in that it aims to make processes more efficient and effective, rather than merely revising them (Jeston and Nelis 2008).

IT is not only a core element of BPM (Rosemann and Vom Brocke 2015). For a long time, the literature has acknowledged IT as a crucial driver for the improvement of business processes (Davenport and Short 1990). IT contributes to BPI and the achievement of the company's strategic objectives by supporting the regular measurement of key performance indicators (Van Der Aalst, Rosa, and Santoro 2016). In general, IT solutions for BPI should be agile, semi-automated tools that are able to continuously self-adjust processes based on contextual changes (Rosemann and Vom Brocke 2015). Prior research has found that typical IT-centred initiatives for BPI that positively affect firms' customer responsiveness and product/service innovation are data integration, communication network connectivity and communication network flexibility (Bhatt and Troutt 2005). Such initiatives stress the central role played by technology and IS in the improvement of business processes and the achievement of net benefits (e.g. costs savings, additional sales). Net benefits are the best measures of process improvements driven by the implementation of an IS, because they 'capture the positive and negative impacts' of a given information system on business performance (Delone and McLean 2003).

These BPI initiatives, furthermore, largely overlap with the key principles and drivers of the ongoing fourth industrial revolution (the so-called 'Industry 4.0'), which has pushed several firms to perform radical digital transformation over recent years. Typical base technologies in Industry 4.0 are cloud computing, internet of things (IoT), cyber-physical systems (CPSs), and big data analytics. This industrial revolution 'involves connection and integration of digital/virtual and real/physical world through CPSs and IoT, where intelligent objects constantly communicate and interact with each other' (Fatorachian and Kazemi 2018, 2). Industry 4.0 is based on four design principles: connections, technical assistance, information transparency and decentralised decisions (Hermann, Pentek, and Otto 2016). Thus, companies that implement these technologies to redesign their business processes and business model are performing digital transformation. The improvement of business processes is a very common (and expected) operational change in the organisations implementing such a transformation (Hess et al. 2016).

Platforms are crucial tools for achieving a digital technology-driven BPI. According to the socio-technical view, a digital platform is a set of technical elements (of software and hardware) and associated organisational processes and standards (de Reuver, Sørensen, and Basole 2018, 127). Long-established organisations use such platforms to run operations, implement innovation strategies, and improve external business relationships and/or internal processes (Esposito De Falco et al. 2017). For example, research about the adoption of digital platforms (e.g. electronic data interchange and enterprise resource planning systems) for the improvement of communication and integration among various supply-chain members is extensive and long-standing (Attaran and Attara 2007; Roh and Hong 2015). In Industry 4.0, digital platforms shared with other company units, suppliers and customers are still the basic front-end technologies by which firms build and manage smart supply chains (Frank, Dalenogare, and Ayala 2019). Companies widely adopt digital platforms, such as Workplace by Facebook, for improving internal communication and collaboration with partners (Snow, Fjeldstad, and Langer 2017).

The literature offers several pieces of evidence of BPI being delivered via digital platforms in both service and manufacturing industries. For instance, a few years ago, DBS Bank in Singapore performed an in-depth digital transformation strategy via its enterprise platform. The main goal of this change was an optimisation of the data, to provide innovative and better experiences to customers. As a result, DBS greatly improved customer satisfaction (e.g. by reducing queue time by 50%) and customer relationships (e.g. by reducing customer complaints by 17% in just one year) (Sia, Soh, and Weill 2016). Another interesting case comes from the automotive industry: Toyota Motors largely used digital platforms in order to better serve customers and be better connected to suppliers. Such platforms made Toyota Motors' processes (particularly marketing and new product development) more reliable and efficient (Su, Levina, and Ross 2016).

In sum, digital platforms are central and powerful solutions for the improvement of both the operation and supply-chain processes of its adopters, provided that these IS are used within a formalised and wider strategic framework of digital transformation.

2.2. Port community system

Port operations are particularly exposed to BPI involving different stakeholders with various – and often conflicting – needs and expectations (Ferretti and Schiavone 2016). The competitive scenario of the maritime industry has evidenced some critical changes that specifically affect operations management in port areas, such as: (a) the growing tendency to resort to economies of scale in vessel-size gigantism (Parola, Satta, and Caschili 2014; Haralambides 2019); (b) the development of shipping consortia and global alliances (Notteboom et al. 2017); and (c) the technological innovations based on the Intelligent Transport System (Sładkowski and Pamuła 2016), in order to support the port community (Marek, Campbell, and Bui 2017; Fedi et al. 2019).

The evolution of maritime clusters has in fact transformed the ports into multi-actor arenas (Parola et al. 2018), thus redefining the role of key players present in port networks (e.g. port authorities, shipping companies, terminal operators, transport services providers and logistics companies). In particular, Port Authorities (PAs) today have a critical role in port governance as meta-orchestrators of maritime activities, based on multifaceted strategic guidance in port development (Parola et al. 2018), are responsible for coordinating the economic players to improve their business processes. According to a study of port devolution (Brooks and Cullinane 2006), PAs can be considered as hybrid organisations acting in the intersection of the public and private domains (Koppell 2006; Parola et al. 2018). From this perspective, PAs must promote the adoption and implementation of complex ICT systems that are required to strongly support seaport operations managed by several port users, in accordance with the Port Authority's scope of jurisdiction (Tijan et al. 2012), and to facilitate data integration in port management. Marek, Campbell, and Bui (2017) has underlined that the adoption of digital platforms in the port industry can be principally supported by private stakeholder initiatives (a bottom-up business model; for example, the Port of Hamburg), public stakeholder efforts (a top-down business model; e.g. the Port of Rotterdam), or a private-public partnership (a PPP business model; e.g. the Port of Genoa).

In recent years, many ports have been adopting the Port Community System (PCS), a digital platform that supports the intelligent and secure exchange of information between public and private port users in seaport communities. The platform can support the custom processes in port management defined by EU normative legislation , which required the adoption of port portals that enable key users to access digital services (Baron and Mathieu 2013) through just one platform (Electronic Single Window: ESW). This is based on the concept of Single Window, defined by the United Nations Economic Commission for Europe as 'a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single-entry point to fulfil all import, export, and transit-related regulatory requirements' (UNECE 2004). For maritime transport, the Nation Single Window (NSW) is considered the environment for collection, dissemination and exchange of vessel reporting information, via a structured and commonly defined data structure, rules and management of access rights, which are in accordance with relevant international, national and local legal requirements (Directive 2010/65/EU). The PCS, as a trade facilitation tool and gateway to the NSW, links the administrative and operational procedures electronically via the exchange of messages on an end-to-end basis (machine to machine) with all port stakeholders (IPCSA 2015). These may include the customs activities, vessel traffic control, inspection authorities, maritime authorities and trade.

In particular, PCS enables the improved efficiency of port logistics processes through a single submission of data, which digitally connects the transport and sea–land logistics chains (Carlan, Sys, and Vanelslander 2016). Some studies (e.g. Di Vaio and Varriale 2020) have provided evidence that PCS supports the port processes related specifically to business-to-business (B2B) and business-to-customer (B2C) activities, with relevant positive implications for the whole port supply-chain. In some cases, the PCS has been developed complementarily with ESW, in order to also support business-to-administration (B2A) and administration-to-administration (A2A) activities.

In his pivotal study, Keceli (2011) identified the three key functions of PCS: (a) port-related document submission (cargo terminal); (b) customs-related document submission (customs office); and (c) e-business functions among port users (e-government portal). The study evaluated the presence of these functions by comparatively analysing five ports: Singapore, Hamburg, Hong Kong, Rotterdam and Busan. The findings demonstrated that not all of the investigated systems offered full services as required by the port users, in terms of PCS service quality, user satisfaction and presence of unique benefits.

In the port management literature, many studies have analysed the critical success factors of PCS implemented in specific national contexts. For example, Rodon, Ramis-Pujol, and Christiaanse (2007) evaluated the evolution of the digital standardisation process of the Port of Barcelona; Polydoropoulou et al. (2011) investigated the critical determinants that supported the performance of the Port of Thessaloniki's container terminal; and Tijan et al. (2012) analysed the Croatian seaport's ITC integration. In recent years, in order to sustain their knowledge-based competitive advantage in global logistics networks, some ports have been developing innovative IT platforms to improve business processes, keep abreast of the current state of the art, and support the intermodal chains of maritime port logistics (e.g. railways and motorways); this is achieved through the adoption and integration of Intelligent Transport Systems technologies (i.e. clouding, internet of things [IoT], horizontal and vertical integration, simulation, and big data analytics) and new systems of communication (e.g. the intranet solution and customised applications). Some studies have investigated the reasons for developing innovative PCS (e.g. Carlan, Sys, and Vanelslander 2016), and found that the main goals of these new systems are: (a) to support the efficiency and effectiveness of information-flow management; (b) to improve the monitoring processes of the import/export activity by customs services, to create unique benefits for port users; and (c) to create a source of competitive advantage for the entire port community, by adopting balanced scorecard models (Ferretti et al. 2017).

In fact, the creation of a successful PCS must allow port users to have a modular and scalable quality system that guarantees ease of use, user satisfaction, and the achievement of some economic (e.g. decreased cost of accessing information) or functional benefits (e.g. multiple access to real-time information). Consistent with Bhatt and Troutt's (2005) study on BPI, the empirical evidence shows that PCS adoption and implementation could generate some benefits for the entire port community (Carlan, Sys, and Vanelslander 2016), in terms of data integration (e.g. reduced rate of inconsistency, decreased rate of errors), communication network connectivity (e.g. fast access to information, reduced cost of communication, compliance with community standards and regulations), and communication network flexibility (e.g. efficient use of resources, customised value-added services).

In sum, the previous literature has highlighted that a PCS must reflect in its architecture and functions the complexity of a port, in order to fully improve operations at both the individual operator and system levels. By adopting a managerial perspective (Bitner 1995), in the following sections we present a specific model for evaluating how PCS improves the business processes of the main stakeholders of a port.

2.3. Theoretical speculations

At this stage, we can develop some theoretical speculations about the heterogeneous advantages and BPIs gained by the various groups of port stakeholders via PCS. The effective adoption and use of digital systems by complex inter-organisational networks, for data exchange and communication, is a key factor in improving the overall quality, performance and outcomes of any business process, at both firm-level and network-level (Bhatt 2001). We were inspired by the findings of the recent literature review by Graça and Camarinha-Matos (2017), regarding the performance of business processes in collaborative ecosystems, in order to achieve this goal. Those authors, indeed, refer to a list of benefits that can usually be achieved via collaborative networks (Abreu and Camarinha-Matos 2008; Graça and Camarinha-Matos 2017): these benefits comprise costs, risks, dependence, innovation, market positioning, flexibility, agility, specialisation, regulation, and social causes. All these benefits, arising from the collaboration with other business partners, generate specific BPIs in order to explore system, service and information quality (Delone and McLean 2003). For instance, the benefit of agility leads the company to improve the interoperability between processes, products and services; the market position benefit allows the company to improve the outcomes of the negotiation processes for resources purchasing. Digital platforms as PCS are key enablers of such collaboration-driven benefits and, as a consequence, are also crucial drivers for BPIs.

Drawing on these assumptions, firstly we can speculate that the extent and scope of net benefits are likely to differ widely across the various groups of port stakeholders, since their ability to use the digital platform could be dissimilar. Furthermore, different users with different goals and core competencies are likely to evaluate the same processes differently. In the case of PCS, for instance, the platform might be designed to focus intensively and accurately only on certain key processes (e.g. customs, import/export) and provide specific types of improvement (e.g. agility, control). Similarly, BPIs related to market position could be crucial only for some port stakeholders and less useful for others. Therefore, the alignment between stakeholders' core processes and their needs, in terms of sought benefits and the technical (software/hardware) characteristics of the digital platform, should be a crucial condition in order to achieve heterogeneous and relevant BPI for all the various groups of PCS stakeholders.

Second, different benefits might be also desired by stakeholders within the same group. For instance, with regard to the group of public entities using PCS, it is possible to distinguish between (a) compliance and regulatory agencies; and (b) public logistics service providers. These actors are likely to have different incentives to connect, and the benefits they receive may thus vary in scope and nature.[2] Therefore, BPIs gained via a PCS are likely to spread heterogeneously both between the different groups of stakeholders (intergroup heterogeneity) and within the same category of port actors (intra-group heterogeneity).

Third, Industry 4.0 technologies, which are usually implemented in PCS, greatly improve the availability and quality of information for all the platform users (LaValle et al. 2011; Frank, Dalenogare, and Ayala 2019). All the groups of port stakeholders could exploit such rich system information to gain net benefits for both operations management and strategic management. Even though PCS is an operations-centred digital platform (e.g. Aydogdu and Aksoy 2015), its data could greatly support port stakeholders – for instance, in developing more accurate strategic approaches and market analyses. In theory, the strategic value of such data is an important driver of BPI for all the groups of port stakeholders. However, in practice only those groups of port stakeholders involved in strategy formation should be able to exploit PCS data and information appropriately (e.g. regarding information quality required for customs management), and thereby achieve BPIs in their strategic and managerial processes.

In sum, the port stakeholders' concrete opportunity to gain positive impacts from a PCS should also result from the consistency of their core business processes with the platform's technical characteristics and strategic priorities, and from the users' ability to exploit the business-related information collected via the platform for strategic purposes (Hess et al. 2016; Sia, Soh, and Weill 2016; Frank, Dalenogare, and Ayala 2019).

3. Research method

We implemented a qualitative study in order to answer the research question, 'How do the various key groups of port stakeholders gain group-specific BPIs via a Port Community System?'. According to Yin (2009), the case study research method should be used when there are three concurrent conditions: (a) the research question of the study starts with 'how'; (b) the researcher does not have to control external conditions of the case; and (c) the investigation concerns contemporary events. Exploratory case studies can be implemented when the scholars have not formally developed preliminary propositions and hypotheses (Mills, Durepos, and Wiebe 2009). In this article, the unit of analysis is the improvement of business processes in port management via PCS. Indeed, we analysed the four main types of processes presented in the Portbase PCS official website (https://www.portbase.com/en/services/): namely, (1) ships' calls, (2) import cargo, (3) hinterland transport, and (4) export cargo. We performed an information-oriented selection of an extreme case – the Port of Rotterdam – as a 'successful example' of an international port adopting and regularly using such a technological platform.

As suggested by Yin (2009), we used multiple sources of data to increase construct validity: (1) official documents and statistics; (2) archival records and industry reporting related to the PCS adopted in the Port of Rotterdam (Portbase Port Community System); (3) personal interviews conducted with six experts (four academics and two ICT managers), to analyse in depth how the improvement of port business processes via PCS could be managed; and (4) analysis of physical artefacts, focussing attention on key technical characteristics of Portbase Port Community System (https://www.portbase.com/en/services/).

In particular, we performed desk research to seek the secondary data. Official documents, statistics and archival records were collected regarding the role of digital platforms in enabling intelligent and secure exchanges of information between public and private port stakeholders in the Port of Rotterdam. We analysed the impact of PCS on (a) the development of port business processes; (b) the service delivery for stakeholders' groups, in terms of net benefits and the richness and availability of data and information; and (c) the improvement of the efficiency of the seaport communities. For these reasons, we obtained evidence about the process improvements for each group of stakeholders involved. We referred to the list of stakeholders presented on the official website of the platform, and we interpreted and coded the key characteristics of the IT solutions described in the relevant section of the website (https://www.portbase.com/en/services/).

Drawing on the quality dimensions developed by Delone and McLean (2003) (information quality, system quality, service quality), the Portbase services were analysed through thematic analysis (Braun and Clarke 2006). We used the research question for coding, and we associated the themes with the codes based on the key characteristics within each business process identified (e.g. import processes). The software WordStat has been used to identify the codes extracted from the key characteristics of each Portbase service within the official website, via a word frequency analysis. We report an example of the interpretation: 'Notification of Crew and Passengers' represents a key characteristic as the 'Optimum reuse of data'. We extracted the description of this IT solution as a benefit related to the availability of information for a specific group of stakeholders involved in the Rotterdam PCS structure. However, topic model-making through the use of thematic analysis (Braun and Clarke 2006; Gioia, Corley, and Hamilton 2013) might result in some words being associated with more than one benefit; therefore, we screened the emerging elements by categorising them into three main classes of benefits looking back also at the previous literature on port community system (Aydogdu and Aksoy 2015; Carlan, Sys, and Vanelslander 2016; Graça and Camarinha-Matos 2017):

1. Accessibility, Connectivity and Usability for system quality;

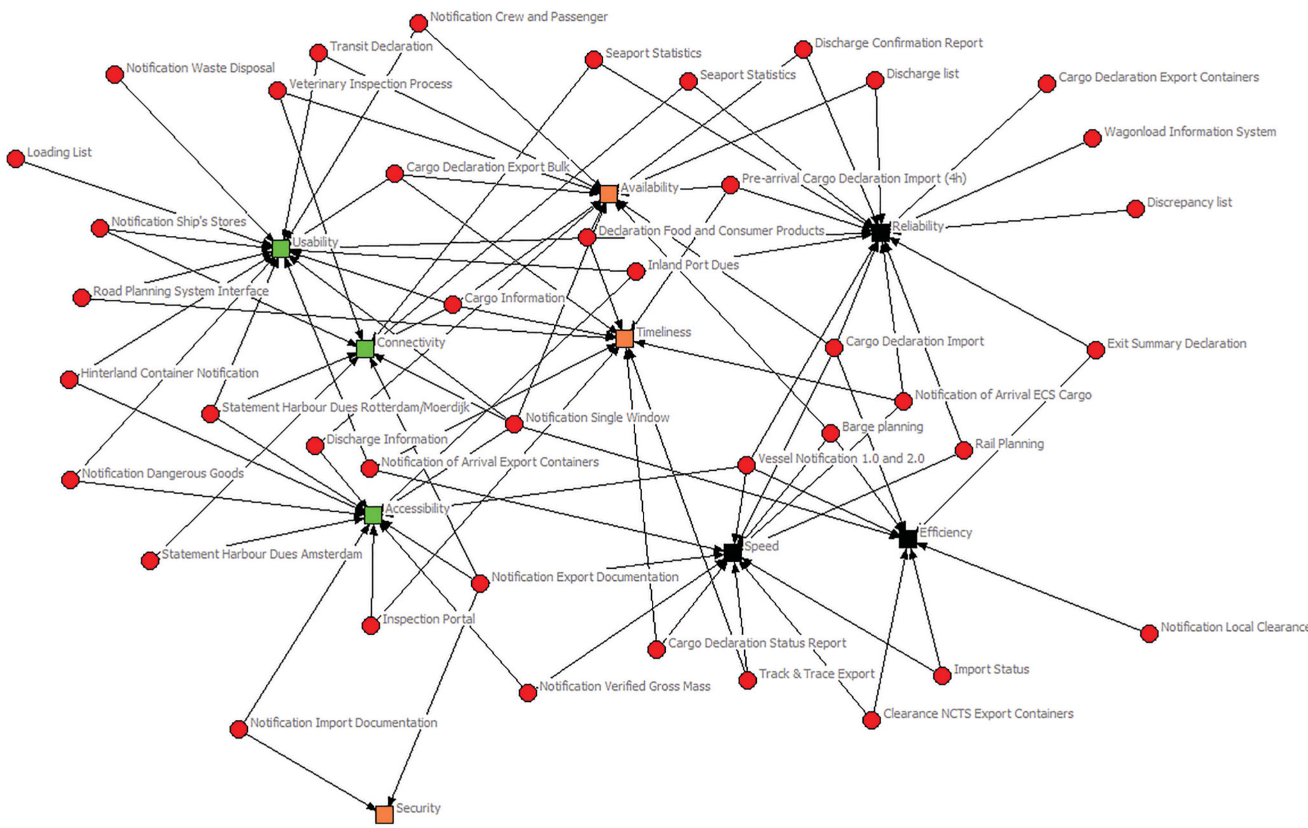

Figure 1. Smart IT solutions and benefits for port stakeholders.

2. Availability, Security and Timeliness for information quality;
3. Speed, Reliability and Efficiency for service quality.

The determination of the main classes of benefits was also validated from the point of view of the six key informants interviewed, all of whom were experts in port operations affiliated with port economics and/or partners in European projects for 'The Port of the Future' (i.e. Call Horizon 2020, Mobility for Growth). Further questions were about the conditions and consequences of implementing new technologies in some port operations, as follows: (a) vessel calls, related to ship operations and logistic processes, by evaluating how PAs – as meta-orchestrators – could be more timely informed about the arrival of a ship, its cargo and country of origin; (b) import/export cargo management, to ensure that the information is provided efficiently and transparently to all the port players involved; and (c) organisation of sea–land logistics processes and hinterland transports, because ports also represent the gateway to and from the hinterland. One specific question about the role of new technologies was also asked, to evaluate (adopting Likert's five-point scale) the importance of clouding, internet of things, horizontal and vertical integration, and big data analytics for developing the port of the future. The average length of interviews was about 60 minutes.

Finally, we analysed the information sheets for each smart IT solution on the official website of Portbase. The results show the association between each smart IT solution and one or more benefits offered by that solution. This is derived from an automatic word-reading/counting performed on the Portbase official documents collected; using the UCINET software to characterise whole networks by linking each smart IT solutions to each associated benefit (see Figure 1); and by associating categories of benefits with types of business processes (Figure 2). Thus, we performed an analysis of the chronological evolution of the new technology-based characteristics of the Portbase PCS of Port of Rotterdam.

4. Case study

The aim of this section is to present the background of the case study analysed. We gathered official data shown in the official website (https://www.portbase.com/en/services) of the Portbase digital infrastructure, which presents 41 smart IT solutions that address specific processes (ships' calls, import cargo, hinterland transport, export cargo) of nine different groups of stakeholders: agents, barge operators, empty depot, exporters, forwarders, importers, road/rail hauliers, ship brokers, and shipping company and terminal operators. The implementation of Portbase is part of a larger digital strategy that the Port of Rotterdam Authority has promoted to improve the overall competitiveness of its port.

4.1. The port of Rotterdam's digital strategy

The port of Rotterdam is the first in Europe, with cargo handling services for 467 million tonnes, mostly made up of dry bulk, liquid bulk, containers and breakbulk. The port is ninth in the world for overall goods handled and eleventh for

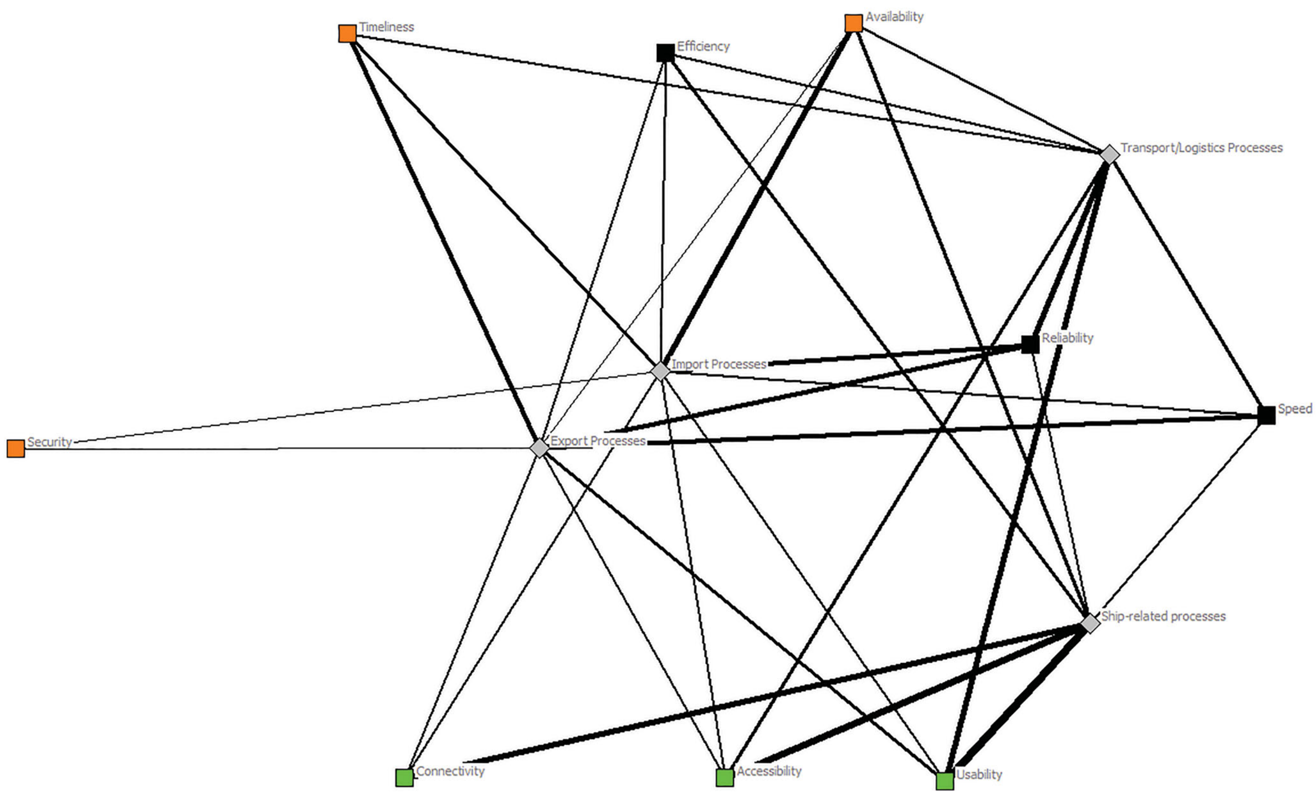

Figure 2. Link between categories of benefits and types of business processes.

goods routed. The added value produced by the port is worth about 21 billion euros (3.1% of the Dutch GDP). Rotterdam is connected with over 1,000 ports in the world, and has approximately 180,000 employees and 3,200 customers in all sectors of the Dutch ports. The exchange of information between hundreds of logistics service providers is the main strength of the business processes of this port. The Port Vision 2030 by the Port of Rotterdam Authority presents the plan for the future of the port, which addresses two major challenges: energy transition and digitalisation. The spirit of this vision can be summarised by the words of Paul Smits, CEO of the Port of Rotterdam Authority: 'Here in Rotterdam, we are taking action to become the smartest port in the world' (https://www.supplychaindigital.com/technology/port-rotterdam-embarks-digital-transformation-programme-ibm). With this aim, the Port Authority (https://www.portofrotterdam.com/en/doing-business/port-of-the-future/digitisation/digital-developments) has identified specific digital strategies that focus on collaboration with all stakeholders to develop new digital products, services and infrastructures (e.g. Portbase PCS, Pronto, Navigate, Nextlogic). Investments in new digital infrastructures (e.g. a digitalisation initiative with IBM) aims to use internet of things (IoT) to create more efficient traffic management at the port (https://www.portofrotterdam.com/en/doing-business/port-of-the-future/digitisation/digital-infrastructure). For these reasons, the Port of Rotterdam Authority collaborates with the main word ICT players (such as IBM, Cisco and Axians), in order to create a digital twin of the port to track ship movements, infrastructure, weather, geographic and water data (https://www.axians.com/en/case-study/rotterdam-becomes-smartest-port-world/). As affirmed by Rotterdam Port Information (https://www.rotterdamportinfo.com/), the new digital infrastructure is expected to benefit all main port users.

The 2017 Annual Report of the Port of Rotterdam shows a gross investment by the Port Authority of 213.8 million euros in customer-related and public infrastructure, and in business assets. It also described the 2017 milestones of the Port Authority, regarding investments in the development of new digital services that can further strengthen port competitiveness. The plan identifies different projects, such as the launch of 'Navigate', which aims to compare various connections, modalities and services to and from the port, in order to fix the optimal cargo routes accordingly.

The Portbase Port Community System (PCS) was created in 2009, through a merger between Port Infolink (2002) in Rotterdam and PortNET (2000) in Amsterdam, to enable a nationwide digital connection platform for a faster and more efficient exchange of information between Dutch and international ports. According to Port Technology, Portbase is 75%-owned by the Port of Rotterdam Authority and 25%-owned by the Port of Amsterdam.

The current digital strategy envisages a wider implementation of Portbase PCS in order to bring port stakeholders an increasing number of advantages, especially related to a greater efficiency and transparency of administration processes, shorter times, reduced costs, fewer errors, and reuse of information. Portbase offers 41 different smart IT solutions; in addition, Port of Rotterdam stakeholders can choose between two different subscriptions (https://www.portbase.com/en/port-community-system/pricing/): Basic (a one-time transaction fee of only €249.50); or Basic Plus (fixed monthly fee with lower transaction costs). Portbase is mandatory for all operators, as established by the Port Information Guide (Port of Rotterdam, April 2018), which requires all kinds of pre-arrival reports and other documentation to be processed using Portbase. The actual level of activities within PCS involves transactions that can be referred to around 3,200 different stakeholders in all sectors of the Dutch ports (https://www.portbase.com/en/port-community-system/). The reliability of Portbase is guaranteed by full compliance with ISO-27000, the standard for information security.

5. Results and interpretations

This section aims to report the BPIs achieved via the introduction of the Portbase PCS in the Port of Rotterdam. The analysis was conducted by applying the identified classes of benefits to illustrate the process improvements obtained by the different types of Port of Rotterdam operators.

5.1. The improvement of business processes in port management via PCS

The multiplicity of actors and business processes that characterise a port system is clearly reflected in the structure and organisation of the Portbase PCS adopted by the Port of Rotterdam (https://www.portbase.com/en/services/). Indeed, several different types of stakeholder can benefit from the use of Portbase PCS. Table 1 presents the description of these stakeholder groups.

The key groups of stakeholders are differently involved in four group-specific business process improvements:

- Ship-related processes (all processes relating to companies and port stakeholders for the management and scheduling of a vessel call, from the notifications of crew and passengers to dangerous goods, and so on);
- Import processes (all processes refer to the purchase of goods from a foreign country (e.g. customs procedures, physical inspections, discharge lists);
- Transport/logistics processes (all processes refer to hinterland transport and logistics for road, barge and rail sectors);
- Export processes (all processes refer to the setting of a broad statement indicating the intention to export, e.g. cargo declarations, export containers, loading lists and notification processes).

Portbase PCS offers 41 smart IT solutions aimed at improving these processes: these comprise 8 smart IT solutions for ship-related processes, 16 IT solutions for import processes, 6 IT solutions for transport processes, and 11 IT solutions for export processes. Table 2 also reports the association between stakeholder groups and types of business processes targeted by each Portbase smart IT solution. Agents, shipbrokers and shipping companies are the main stakeholders' groups using the smart IT solutions provided by Portbase PCS. They use the major part of services provided in the Port of Rotterdam (see Table 2).

To capture systematically the opportunities in terms of BPIs, we analysed how different Portbase smart IT solutions provide different classes of benefits (i.e. Accessibility, Connectivity and Usability for system quality; Availability, Security and Timeliness for information quality; Speed, Reliability and Efficiency for service quality) for each group of major port stakeholders.

We then used these benefits to interpret the characteristics of each Portbase solution. As a result, the map in Figure 1 shows the association between each smart IT solution and one or more benefits offered by that solution. We analysed the information sheets of each smart IT solution on the official website of Portbase, in order to characterise whole networks by linking each solution to its associated benefit (see Figure 1). The aim is to report a diagram of the various smart IT solutions connected in the Rotterdam PCS. As can be

Table 1. Group of port stakeholders in Portbase PCS.

Group of port stakeholders	Description
Agent	An operator who manages the operations of a ship in the port system. Agents are Portbase customers who carries out all fundamental duties requested by the crew of the ship.
Barge operator	An operator who works with machinery and mechanical equipment in order to ensure the quality of operations processes, materials, and other products (e.g. processing container barges).
Empty depot	An essential part of logistics chain: there are a lot of people working in the storage area for empty shipping containers.
Exporter	An operator who makes the export declaration on the exported goods.
Forwarder	An operator or a company that manages shipping processes to get goods from the producer to a market or other local point of distribution.
Importer	An operator that brings goods or services into a country from abroad for sale. With regards to customs procedures, a person who makes the import declaration on the imported goods.
Road haulier and Rail haulier	Operators that transport goods by road / rail.
Shipbroker and Shipping company	The first are specialist intermediaries in ship-related processes, are sitting between shipowners and charterers or buyers and sellers. The second are firms that transports of shipments of goods. Using Portbase PCS, they have been benefitted from smart IT solutions avoiding the need of making changes to their activities. They submit data only once.
Terminal operator	A public or private unit who responsible for the administration of a port terminal.

Table 2. Stakeholder groups targeted by each Smart IT solutions and group-specific business processes.

ROTTERDAM PCS	Group-specific business processes																																							
	Ship-related processes								Import processes																Transport/Logistics processes						Export processes									
Stakeholder groups / **Smart IT solutions**	Notification Crew and Passenger	Notification Dangerous Goods	Notification Ship's Stores	Notification Single Window	Notification Waste Disposal	Statement Harbour Dues Amsterdam	Statement Harbour Dues	Vessel Notification 1.0 and 2.0	Cargo Declaration Import	Cargo Declaration Status Report	Cargo Information	Declaration Food and Consumer Products	Discharge Confirmation Report	Discharge Information	Discharge list	Discrepancy list	Import Status	Inspection Portal	Notification Import Documentation	Notification Local Clearance	Pre-arrival Cargo Declaration Import (4h)	Seaport Statistics	Transit Declaration	Veterinary Inspection Process	Barge planning	Hinterland Container Notification	Inland Port Dues	Rail Planning	Road Planning System Interface	Wagonload Information System	Cargo Declaration Export Containers	Clearance NCTS Export Containers	Exit Summary Declaration	Loading List	Notification Export Documentation	Notification of Arrival ECS Cargo	Notification of Arrival Export Containers	Notification Verified Gross Mass	Seaport Statistics	Track & Trace Export
Agent	■	■	■		■	■	■	■	■	■		■		■			■	■	■	■	■	■	■						■		■		■		■	■			■	■
Barge operator																	■		■						■	■	■								■					■
Empty depot																									■	■			■											
Exporter																							■									■			■			■		■
Forwarder											■	■		■			■		■	■			■	■							■	■			■			■		■
Importer											■	■	■				■		■	■		■		■																
Road haulier and Rail haulier																	■		■						■	■	■	■	■	■		■			■					■
Shipbroker and Shipping company	■	■	■		■	■	■	■	■	■	■	■	■		■		■		■	■		■	■	■							■		■	■	■			■	■	■
Terminal operator													■	■	■		■	■	■	■			■		■	■	■	■	■	■	■	■	■	■	■	■	■			■

seen, most of these smart IT solutions improved (1) the usability of the system, (2) the availability and timeliness of the information, and (3) the reliability of the service for its end-users (e.g. agents, and compliance and terminal operators).

Finally, in order to address the entire research question, the impact of Portbase on the main business processes of Port of Rotterdam stakeholders was assessed. We linked the categories of benefits to the types of business processes (see Figure 2). In this case, the networks are characterised by associating categories of benefits with types of business processes. The results show that the improvements of different business processes are based on different categories of benefits. The width of arches connecting benefits and processes highlights the strengths of the association. For instance, import processes have greatly improved, in terms of availability of information and reliability of the service, through the smart IT solutions of the PCS implemented in the Port of Rotterdam. The following subsections provide a detailed description of the main smart IT solutions that contributed to the improvements of the four business processes analysed.

Possible conflicts may have arisen among different types of stakeholders regarding the security of the information; although these rarely emerged, probably because they are implied. Portbase also allows knowledge-sharing among stakeholder groups through the exchange of the information and data, in order to obtain competitive advantages over the competition, via exploiting the abilities of human resources and the incessant innovations in the system quality. For these reasons, thanks to this digital infrastructure, the types of business processes are improved in different aspects. Many logistics players, such as road operators, rail companies, barge operators, importers and exporters, can improve their business processes using a PCS that facilitates the exchange of data and information.

Although a detailed description of how each IT solution specifically affects different stakeholders' business microprocesses is impractical, some exemplary evidences are provided to help understand the impact of Portbase on the different stakeholder groups. For each type of business process, all IT solutions are mentioned, and most are described. Comments by port stakeholders, taken from the community platform, are reported, which are related to the main perceived benefits. The aim is to identify the classes of benefits, in order to show how these benefits are distributed across stakeholder types.

5.2. Ship-related processes

Portbase provides a series of smart IT solutions that have improved the ships' calls for agents, shipbrokers and shipping companies. The Dutch government requests a list of all persons on board ships entering the ports, not less than 12 hours before their arrival in order to improve the availability and timeliness of the information. This list can be drawn up automatically using the new Portbase technology: the ships themselves send the lists of those present using the services 'Vessel Notification 2.0' and 'Notification of Crew and Passengers'. Other solutions available that improve these processes for agents, shipbrokers and shipping companies include 'Notification of Dangerous Goods', which sends an alert signal in case of dangerous goods, and the 'Statement of Harbour Dues Rotterdam/Moerdijk', which makes it possible to present the information requested by the competent port authorities, and ensures optimal reuse of the information already present in the PCS. The 'Notification of Waste Disposal' notifies the harbourmaster of the presence of waste on board. To ensure greater efficiency of the processes and usability of the system, Portbase operates from two different locations connected via a double fibre-optic connection. All data coming from the PCS is collected and sorted in one position, while at the same time synchronised with a standby database in the other position; this guarantees continuity of the data, even if one of the two parts stops working. An emergency procedure has also been planned for the highly unlikely event that both parts stop working. The goal of Portbase is to put the customer first and foremost; thanks to customer feedback, the services are improved. As stated by John Kaijen of Yellowstar Solutions (a logistics service provider), 'A system interface means two fewer manual operations each time while also reducing the likelihood of errors. From their own back office, companies can use this interface to send messages directly to the Port Community System and to receive messages in return. This means two fewer manual operations each time while also reducing the likelihood of errors. Using Portbase therefore increases efficiency.'

This customer review attests to the process improvements resulting from this first phase; it contains a great amount of information to collect and codify, in order to reduce the risk of errors and information asymmetry. Other evidence has emerged from the official page of Portbase Trade Press. A recent article published on 27 March 2018 reads: 'In terms of its design, 'Notification of Ship's Stores' will be similar to the previously introduced Notification of Crew and Passengers. First, the captain enters the ship's stores into an Excel sheet, after which you – the shipping company, shipbroker or shipping agent – will upload this list to the Port Community System (PCS). We will then forward the data in the correct format to the Single Window for Maritime and Air, previously known as the Single Window for Maritime (e.g. Notification Single Window)'.

The scheduling of the activities ensures that the best practices are attained. The main improvements concern the notification processes, the fast scheduling of a vessel call, the optimal reuse of data and the specific reporting to authorities.

5.3. Import processes

Portbase provides a series of smart IT solutions that improve import processes for several stakeholder groups and increase the reliability of the service for its end-users. The decision to use PCS is due to the numerous advantages that the new technologies (e.g. big data, cloud, IoT) can offer; in particular, the greater efficiency and transparency of import processes, with shorter times, reduced costs, fewer errors, and reuse of information. Thanks to the goods declaration import services ('Cargo Import Declaration', 'Cargo Status Report Declaration', 'Cargo Information', 'Declaration of Food and Consumer Products'), each port stakeholders declares the content of the goods and information within the allocated time. The customs staff signal any errors made and indicate the inspection of the load. For example, the Portbase service named 'Declaration of Food and Consumer Products', targeted at agents, forwarders, importers, shipbrokers and shipping companies, is used if there is a need to declare veterinary goods and high-risk food products. There is also a case in which these products have already been reported through the importation of goods and information on goods declarations; this shows the interactivity and the interconnection between the various solutions, which improve and optimise the practices involving importers. Other IT solutions concern the declarations of the tankers, such as the 'Discharge Confirmation Report', 'Discharge Information' and 'Discharge List', which declare the weight of the goods and other types of information for the stakeholders involved. A detailed analysis is given by a customer, Zlatan Abramovic, of Customs at Rotterdam Rijnmond, as follows: 'The Inspections Portal is aligned with efforts to develop targeted information exchange between the public and private sectors and among parties within the private sector. It shortens handling times considerably with regard to customs inspections for entry at sea-side.' The customer goes on to say: 'Another important bonus is that the portal also makes it possible for us to manually register inspections. These produce exactly the same messages and notifications as the automatically generated inspections. Then, while awaiting inspection, the containers (i.e. goods) are automatically blocked in the respective computer systems of participating terminals. Other IT solutions are 'Discrepancy List', 'Import Status', 'Inspection Portal', 'Notification of Import Documentation', 'Notification of Local Clearance', 'Pre-arrival Cargo Import Declaration (4 h)', 'Seaport Statistics', 'Transit Declaration' and 'Veterinary Inspection Process'.

Stakeholder groups benefit hugely from the usability of this platform, which in this case is able to improve the import processes, making them more transparent. Indeed, as another review stated, 'The dashboard in the Inspections Portal gives us, at a glance, a real-time overview of all customs inspections currently in progress' (Jurjen Stoorvogel, Customer Service Manager with Evergreen Shipping Agency).

5.4. Transport/logistics processes

BPI regarding the dynamics of transporting goods in the national territory are made possible thanks to Portbase's smart IT solutions, although these are tailored differently to the other stakeholder groups. For instance, the 'Hinterland Container Notification' service, which is targeted at the barge operators, rail operators, rail hauliers and road hauliers, is currently being drafted; it will soon replace the current service, and form the modes of transport (trains, trucks) for loads. The IT solution named 'Barge Planning', for barge operators, empty depots and terminal operators, makes it possible to easily make an appointment with the container terminals. New technologies help to improve transport/logistics processes by sending the electronic loading and unloading lists to the terminals; furthermore, information on the availability status of these containers is received. Other smart IT solutions are 'Inland Port Dues', 'Rail Planning', 'Road Planning System Interface' and the 'Wagonload Information System'. For example, through 'Road Planning' for rail operators, rail hauliers and terminal operators, the arrival of goods at the maritime terminals is signalled, so that the station is ready and there is the shortest delivery time for the driver at the terminal. Other evidence emerges from the official page of Portbase trade reporting. A recent article published on 15 June 2018 reads as follows: 'Portbase will switch all road hauliers who use the Road Planning service via the internet over to Hinterland Container Notification. This new service will make submitting your pre-notifications to the container terminals easier and faster. In total, some 1,100 road hauliers will be switched to the new service. The first 350 of these have already made the move.'

One of the main advantages of Portbase is the service speed that improve the reliability for its end-users. 'Pre-notification of a container can be done with a single press of a button. The Port Community System is indispensable for anyone transporting containers to and from Rotterdam,' stated Peter de Hon of EasyTrip. He then went on to say, 'The automated Portbase interface saves a great deal of time – typically, something in short supply among hauliers. This evidence demonstrates the improvement of these business processes, especially in-service speed; indeed, automatic feedback makes it possible to always be updated, in order to avoid any unnecessary trips. Regarding these processes, the main improvements for port stakeholders relate to rail, barge and road activities.

5.5. Export processes

By using the 'Notification of Export Containers Arrival' solution, the container terminals can electronically release the documents for loading out of customs. All other documents are then eliminated, and it will be enough for the client to have been notified in advance through the mentioned service. The document will be issued once the container arrives at the terminal. This guarantees a more correct management of documents, avoiding 'dead times' between terminal and customs also improving timeliness of the information. Indeed, Niels Dekker, Public Affairs & Communications Manager of Rotterdam World Gateway, stated the following in a review of the solution 'Clearance of NCTS Export Containers', targeted at the forwarders, exporters, terminal operators and road hauliers: 'We are the first deep-sea terminal to be awarded the customs permit 'Authorised Consignee'. This means we are able to electronically release pre-notified NCTS containers at customs via the Portbase service 'Clearance of NCTS Export Containers'. Truck drivers no longer have to stop at customs to hand over the NCTS document. The same is true for containers on trains and barges.'

Table 3. Key findings of the case study.

	Peculiar factors
Role of the digital strategy	• Definition of the digital platform scope in terms of types of stakeholders allowed to access • Definition of the width of the set of services offered by the digital platform in terms of different business processes addressed
Types of net benefits for adopters	• Identification of the net benefits related to individual stakeholder processes • Identification of the net benefits related to multiplying effects via processes interdependencies and network externalities
Quality relevant aspects	• Analysis of the contribution of each aspect of the quality at system, information and service level • Analysis of the specific dimensions for each aspect of quality

The majority of IT solutions are targeted at the forwarders, exporters, agents, shipping lines and cargo handling agents, to assist in handling export practices.

The Port Authority of Rotterdam, the Port of Amsterdam and Statistics Netherlands (CBS) obtain monthly data on travel and goods through the Seaport Statistics service. The data are based on information previously provided by the shipping companies anonymously, and which are already available in the Port Community System; this makes it possible to acquire useful statistics in relation to cargo flows. In summary, the improvements relate to customs procedures, inspection processes and the use of statistics in real time.

6. Discussion

The case of the Portbase PCS highlights the specific factors that affect the success of a digital platform in improving the processes of a network of different stakeholders. The study contributes to the field of literature pertaining to the implementation of a PCS (Aydogdu and Aksoy 2015; Carlan, Sys, and Vanelslander 2016; Graça and Camarinha-Matos 2017) by exploring the various classes of benefits achieved by the different stakeholder groups using this particular type of digital infrastructure. Three key findings emerge from the case study, which deserve some attention.

First, as for any digital technology, Portbase PCS's introduction is the result of a digital strategy. However, unlike the implementation of a new information system by a single organisation, where the organisational boundaries are clearly defined and the business processes are well identified, the introduction of a digital platform aimed at a community of stakeholders is driven by certain peculiarities. The actor introducing the platform is not the only user and beneficiary of the new information system. To succeed, the platform must be 'adopted' by a large set of independent actors that have to perceive its services as useful for supporting their specific business processes. Therefore, a clear understanding of the real needs of platform users, and a careful design of the digital services provided to them, are essential. This problem is exacerbated in the case of a port system where the heterogeneity of actors is very high. To address this problem, the Rotterdam Port Authority adopted a digital strategy aimed at maximising the impact of Portbase PCS for public logistics users, by expanding both the reach and the networking capabilities of the platform (the number of connected users) and the platform responsiveness (the adaptability of the services to different port stakeholders). To expand the reach, Rotterdam PA established a joint venture with the Amsterdam Port Authorities, thus enabling them to also address port operators outside the Rotterdam port system. To expand responsiveness, Rotterdam PA designed a platform that offers a very broad range of digital services (41 in total), thereby increasing the possibility of each port stakeholder self-assembling the set of services best suited for its own business processes.

Second, Portbase PCS's capacity to improve port stakeholders' business processes is related to a portfolio of smart IT solutions that are able to enhance the system quality, information quality and service quality. It appears from the analysis of the 41 services that most of them improve more than one of these dimensions. For example, the smart service 'Notification of Export Containers Arrival' increases all three dimensions, whereas 'Notification of Crew and Passengers' benefits system quality and information quality. Only six services appear to affect only one of the dimensions we considered. From our findings, it appears that a highly efficient IS must improve all three aspects of quality; that is, quality of the system, of the information, and of the service.

Third, the benefits offered by the different services are targeted at the specific characteristics of the business processes carried out by different stakeholder groups. Indeed, the different benefits provided by the platform are not equally related to services, but are mostly concentrated in those services that address a specific business macro-process. For example, the benefit of higher usability of the system is provided especially by those services that address the ship-related processes, whereas the benefit of higher availability of information is provided by those services that address import processes. The targeting of benefits to business processes highlights the importance of designing a platform with a precise view of the needs of the different groups of port stakeholders, and a clear understanding of the specific value-drivers related to each business process. The wide variety of the services offered by Portbase PCS, on the one hand, offers the possibility to select the mix consistent with the specific processes of the user; on the other hand, it provides the port stakeholder with a mix of benefits that improves the processes in critical aspects. The case study findings are summarised in Table 3.

7. Conclusions

The role of digital platforms in improving adopters' business processes still requires further theoretical and empirical investigation. In this article we argue that three specific aspects deserve particular attention, in order to fully capture the impact of this platform: (a) the digital strategy adopted by Port of Rotterdam, aimed at expanding the reach and responsiveness of the platform; (b) the effect of the services on system, information and service quality, as the three key dimensions of IS quality; and (c) the targeting of the benefits provided by the platform to the specific business processes of stakeholders' groups. These findings contribute to a better understanding of how a digital platform can improve operations for its adopters.

From a theoretical perspective, we further validate the ability of recent models, such as by Graça and Camarinha-Matos (2017), to explore performance indicators for collaborative business ecosystems. In such a context, we extend previous research by highlighting the relevance of specific strategic decisions related to the reach and responsiveness of the platform, and the importance of facilitating group-specific business process improvements via a Port Community System; these benefits being targeted according to the stakeholder group's specific characteristics.

We also show that to understand the role of digital platforms in BPI, it may be interesting to use the stakeholders' business processes as the unit of analysis, rather than adopting the perspective of the platform provider (the PA in our case study), which is commonly employed in the extant literature. Indeed, in an ecosystem of business actors (such as those of port operators), the improvements of the business processes obtained by the use of a digital platform are both a prerequisite and an outcome of the implementation.

From a practical perspective, our study provides port managers with an accurate snapshot of all port processes that can be improved via PCS. By leveraging our analysis, PA managers can identify the processes in which improvement can be beneficial for the port system operators, evaluate the impact of implementing a digital platform on different aspects of those processes, and focus their attention on the most critical aspects of the system, service and information quality.

Although this study is located in a specific context, that of the Port of Rotterdam system, its results can be extended to other PCS ports, or eventually to other similar digital platforms adopted in different industries. Future research developments may include: an in-depth analysis of the effect of different digital strategies on the success of PCS or of other similar digital platforms; the empirical measurement of the indirect benefits generated by process interdependencies and network externalities in PCSs or in other platforms; and the assessment of the relative weight of each dimension of quality (system, information and service levels) on the BPI of different platform users. In addition, future studies may also consider the adoption of alternative theoretical models to measure the success of a digital platform, with the aim of identifying different factors that can improve the processes of a network of interconnected stakeholder groups.

Notes

1. This paper is the inseparable result of a co-operation between the authors. However, Sections 2.1 and 2.3 by Francesco Schiavone; Section 1 by Francesco Schiavone and Junsong Chen; Sections 5 and 6 by Michele Simoni; Sections 2.2, and 3 were written by Marcello Risitano; Section 4 (and its sub-sections) by Daniele Leone.
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Notes on contributors

Michele Simoni holds a PhD in Business Management and is Professor of Marketing and Business Model Innovation at the Department of Management and Quantitative Studies, *Parthenope University of Naples*. He has been a visiting scholar at the *China Europe International Business School (CEIBS) – Shanghai* twice and at *University of South Wales (UNSW) – Sydney* twice. Prof. Simoni serves as coordinator of the theme division of Italian Marketing Scientific Society (Società Italiana di Marketing - SIM) on Technology and Innovation Marketing. His research currently focuses on how complexity affects innovation and value creation processes in entrepreneurial and managerial organisations.

Francesco Schiavone is an Associate Professor in management at University Parthenope, Naples, Italy. He received the Ph.D. degree in network economics and knowledge management from the Ca' Foscari University of Venice (Italy) in 2006. He is also an Affiliated Professor in innovation management at Emlyon (France). In April 2017 Prof. Schiavone has been habilitated as Full Professor in management by MIUR (Italian Ministry of Education and Research). Currently, his main research areas are technology management, strategic innovation, communities of practice, and healthcare management and innovation.

Marcello Risitano (Ph.D. in Business Science, Federico II University of Naples, Italy) is an Associate Professor of Management at Parthenope University of Naples. His research and teaching interests is focussed on strategic and marketing management, tourism industry, maritime logistics management. He coordinates numerous research projects on these topics. Marcello's works have been published across some international peer-reviewed journals, such as *Production Planning and Control*, *Transport Reviews*, *International Journal* *of Transport Economics*, *Transportation Research – Part A*, *International Journal of Culture Tourism and Hospitality Research*, *British Food Journal*. Since 2016, Marcello Risitano is Scientific Director of MAR.TE. Laboratory – Sea-Land Logistics.

Daniele Leone, PhD, is a Research Fellow at the Parthenope University of Naples, Italy. He received his doctoral degree in management from the University of Naples Federico II in February 2019. In 2017 he was a Visiting Scholar at the Norwich Business School, University of East Anglia, Norwich, UK. In 2015 he received the master's degree in International Marketing and Management from Parthenope University, Naples, Italy. He is also a member of the editorial board of the International Journal of Globalisation and Small Business. His main research areas are innovation management, crowdfunding and healthcare management.

Junsong Chen is the Professor of Marketing at Emlyon Business School, France. He received his Ph.D. in Marketing from University of Birmingham in 2003. He has been a visiting scholar at SDA Bocconi School of Management, Italy. Prof. Chen is on the Editorial Board of the *Journal of Global Scholars of Marketing Science* and the *Journal of Customer Behaviour*. Currently, Prof. Chen's main research interests lie in the areas of service marketing, open innovation, strategy and CSR.

ORCID

Michele Simoni http://orcid.org/0000-0003-1669-3676
Francesco Schiavone http://orcid.org/0000-0001-9219-6714
Marcello Risitano http://orcid.org/0000-0001-9579-5931

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