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Analysing Port Community System Network Evolution

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ABSTRACT

Ports have played an important role in facilitating exchanges among countries since the day when inland transportation was poor. As ports become hubs for global supply chain, they have to maintain their competitiveness not only by reassuring their efficiency, reliability, accessibility to hinterland, and sustainability. In addition, there is a constant challenge from all operational parties of the port to acquire needed information or to trust information received, due to multiple legacy systems and platforms that do not integrate with each other, and to the lack of real time updates. There are differing agendas between parties and, sometimes, distrust within the multi-stakeholder ecosystem leads to working in silos. This jeopardizes seamless data exchange and cooperation across the port value chain, resulting in significant inefficiencies. Port community system (PCS) can enhance communication and simplify administrative process resulting economic and environmental benefit for actors in the supply chain. The invisibility of the benefit, actors' heterogeneity and significant investment to develop the system resulting a reluctance in implementing PCS. This chapter aims to study the evolution mechanism behind the process of PCS network development using lesson learned from industrial symbiosis network development and network trajectories theory. The PCS network development following serendipitous and goal-oriented process that can be categorized into three stages: pre-PCS network, PCS network emergence and PCS network expansion. This chapter contributes to the exploration of network evolution and documents lesson learned to foster PCS implementation.

KEYWORDS: port community system, port community members, network trajectory, goal-oriented, serendipitous network.

1. Introduction

More globalised economies remove barriers of international trade that eventually prosper from maritime transport. The possibility of transporting goods in high volume emphasizes the importance of maritime transport. Hoffmann and Kumar (2010) categorised transportation as one of four foundations of globalization together with telecommunications, international standardization, and trade liberalization. This trend transforms seaport role into a crucial hub in the supply chain that connects diverse stakeholders who engage in different activities based on their interest. This shows a notable difference compared to seaports' role in the past as a local institutions assist its own hinterland (Keceli, 2011). Seaports face constant challenges in maintaining their competitiveness in serving assorted stakeholders involving in multiple supply chains. Thus, the competition is not between individual stakeholders running business, but between supply chains (De Martino, Morvillo, & Martino, 2008). The main challenge of seaports is due to rapid exchange of information, physical, and financial among stakeholders making the study on information exchange is important since other process, including physical exchange, depends on the seamless information flow (van Oosterhout, 2008). Failing to process the information correctly in a timely manner can cause a delay that is translated into financial loss and a chain reaction affecting other business. Ports' location becomes less important in the term of competitive advantage, instead the quality of their physical (hardware) and service (software) infrastructure to maintain added value in serving supply chains plays a major role (van Baalen & Zuidwijk, 2008; De Martino et al., 2008).

This port complex networks entails an integrated system service to accommodate a transparent information exchange among all stakeholders involved in the supply chain. Port community system (PCS) is explicitly seen as a means to improve seaports operation by reorganising how the information flows. This can decrease the delay of the goods movement by reducing documentaries processing time rather than physically expand the ports area (Long, 2009). Physical expansion will only increase the physical, financial and information flow without targeting the main problem and will worsen the condition.

The absence, or limited implementation, of PCS and relaying information exchange through conventional system is prone to mistakes. Error during multiple manual entry, missing documents, documents duplication, or not receiving real time information are some of preventable mistakes in seaports operation. Nonetheless, PCS implementation can be challenging. Some stakeholders may lack of resource to implement PCS and see unequal benefit among them from PCS implementation. In addition, trust to cooperate and disclose information for the common benefit is a major issue that can hinder stakeholders' participation. This can be rooted from stakeholders' multiple roles in the supply chain and may see others as partners and competitors at the same time.

PCS is not an entirely novel infrastructure in seaports and its development attract more scholars to conduct research. Previous multiple studies focus on the benefit gained from PCS implementation, especially in the term of time saving and paperwork reduction (e.g. Keceli, 2011; Tijan et al., 2012; Aydogdu and Aksoy 2015). However, the overall study on PCS is still relatively low, especially on the best practice of PCS implementation. This is highlighted by Srour et al. (2008), who stated that the most relevant studies on it were from technology deployment life cycle on inter-organisational information system (IOS) along with government report on intermodal technology deployment and PCS implementation. Thus, this chapter researches on the network formation in implementing PCS technology where we derived the lesson from industrial symbiosis (IS). Although PCS and IS are two different system aiming at completely differing objectives, the establishment entails certain degree of inter-organisation collaboration and information exchange. Moreover, IS is more established and widely studied providing useful information for network development for PCS implementation. Other insight that will be utilized is network trajectory theory.

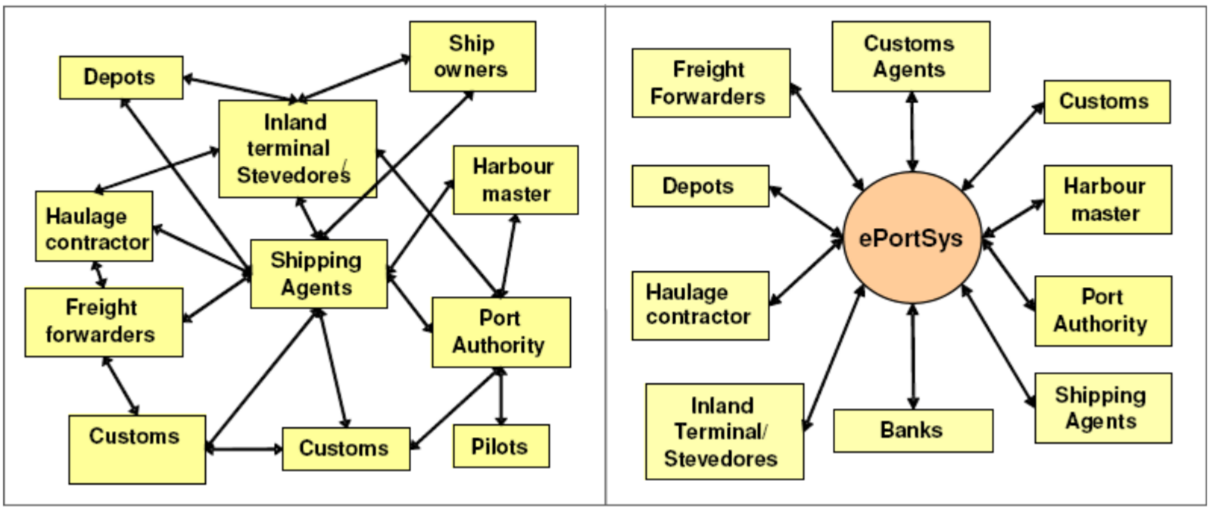
This chapter conceptualises network evolution in PCS implementation that is built on the insights received from literature review and experts. The organisation of this chapter is as follows. Section 2 presents a general overview of PCS including its brief history and technological aspects such as architecture types, functionalities and modularity. Section 3 presents an overview on symbiosis development: a lesson learned from IS development and network trajectories theory. Section 4 presents evolution on PCS network development including stages development, type of trajectories, challenges in every stage and determining aspects. Finally, Section 5 presents conclusions and possible future research direction on PCS network development.

2. Port community system

Ports can be defined as hubs for informational, logistical, financial, and spatial that are entrenched in global supply chains where they provide services to the networks and to the interests of geographical region and nation (van Baalen & Zuidwijk, 2008). Within geographical vicinity surrounding ports, economic activities take place among public and private entities that form port community (Wrigley, Wagenaar, & Clarke, 1994).Various entities surrounding port region are part of the long global supply chain in which their activities require coordination.

The importance of ports in the European Union (EU) is mostly for short sea shipping (SSS) that is accounted for nearly 60% of all cargo movement within EU (European Commission, 2018). Short sea shipping (SSS) in the context of European Union is a maritime transport in a short distance which occurs between ports in the EU countries (European Commission, 2014). Because merchandise movement inside EU countries occurs in relatively short distance, it creates a competition among various transportation modes. This resulted in a call from European Commission (EC) to reduce administrative work in ports in order to maintain the attractiveness of ports and maritime transport service in competing with other transport mode that requires less control and coordination. EC launched e-maritime initiative in order to foster the development of port system that will allow port community to better coordinate, access required service, and reduce administrative burden.

The need of a system that can coordinate maritime network, overcome uncertainty, and reduce administrative burden has been recognized since 1980s where the first inter-organisational information system that can centralise messaging system and transcribe various format was materialized and called PCS (Port Community System) (van Baalen & Zuidwijk, 2008). This was the time when port of Felixstow planned PCS, FCP80 (Felixstow Cargo Processing for the 80s), due to overload throughput leading to burdensome documentary process related to the clearance and cargoes movement (Long, 2009). PCS is defined as an open and neutral electronic platform that links multiple systems operated by assorted organisations that form a seaport community in order to improve competitive advantage (Rodon & Ramis-Pujol 2006; IPCSA, 2011).



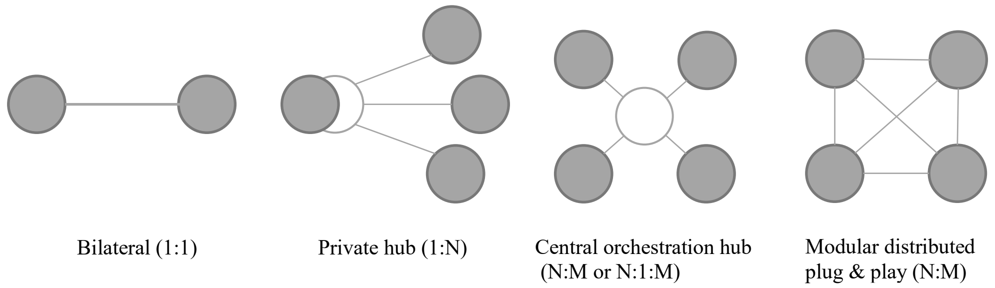
Communication without PCS

Communication with PCS

Fig. 1 Conventional system (left figure) vs PCS (right figure) (Rodon & Ramis-Pujol 2006)

Conventional documents handling takes place in the absence of PCS (Fig. 1). Tijan et al. (2012) and Aydogdu & Aksoy (2015) provide examples on conventional document handling in Croatian and Turkish Ports. The ports in the aforementioned studies are employing paper-based methods through fax, voice mail, email or direct handing documents in which the documents are exchanged multiple times in various transaction involving as many as ten parties in port community members (PCM). Conventional system will also require daily coordination meeting among PCM. This process infers high cost, errors, and inefficiency. Prior to Felixstow port applying PCS in 1981, the clearance process would take four to five days with one out of three declarations having errors (Long, 2009).

The benefit gained by each stakeholders adapting PCS varies but it can be optimized by suitable system design in order to enable a seamless information exchange. Srour et al. (2008) classified four different types of system architectures in PCS (Fig.2). The first type is bilateral type or one-to-one connectivity. The connection works well between two parties who exchange information heavily and can be considerably cheap since it is usually involving basic communication by e.g. phone or fax. Upscaling will be a major problem because point-to-point connectivity among multiple parties will require high number of connections. Private hub is the second architecture type. Connection among multiple parties will be established through the hub that will decrease the number of connections needed. In this type, the dominant party in the community usually initiates and owns the hub. The third type, central orchestration, is similar compared to the second type except independent party out of the network runs the hub. Modular distributed plug and play is the last architecture type. There is no permanent linkages and parties can connect with each other when interaction is required. Connection capabilities and system integration is design to be fast.



a b c d

Fig. 2 Different inter-organisational information system architecture: bilateral (Fig. 2a), private hub (Fig. 2b), central orchestration hub (Fig. 2c) and modular distributed plug and play (Fig. 2d) (Srour et al., 2008)

Other authors (see Carlan, Sys, & Vanelslander, 2016) have described PCS design based on its functionality and modularity. Those functionalities cover logistics, navigation, dangerous cargo declaration and customs. Logistics function provide seamless information exchange throughout the supply chain without compromising data confidentiality. Navigation function helps with the plan and optimization for vessel arrival and departure. Dangerous cargo declaration functionality will assure the efficiency on hazardous cargo declaration through electronic information exchange. The last function, customs, will simplify the administrative work-related export and import procedure. These functionalities differ from ports to ports. It is affected by the dominant stakeholders leading to the functionalities that mostly relate to their concern (Keceli, 2011). PCS modularity is an addition to functionality. This is an approach on how each of functionality is broken down into more specific structure. The vessel who is going to Berth need to submit the information through specific module on the navigation function, meanwhile custom declaration information needs to be submitted on module under customs function. This set up allows the information to flow through proper channel and received by related stakeholders who is interested or responsible for such information (Carlan et al., 2016). System modularity is considered important aspect in PCS development since the number and the needs of port community members can grow. The system needs to be flexible enough to be integrated with other existing information system or to be expanded when there is a need in new functionalities.

3. Symbiosis development

In each scheme of PCS implementation, network development among community member is crucial. It implies a symbiosis in which relationship occurs between unrelated entities involving certain extent of support either both-ways and one-way. In the context of IS and PCS, the relationship needs to be beneficial for all parties and the supports are available in the form exchanging material, energy, water, information for IS and information for PCS. The nature of exchange between these two systems are different, as well as their objectives. Nevertheless, there are two common features of IS and PCS namely network development as prerequisite condition and common benefit as the aim. PCS will need as many as possible PCM to work together in order to gain common benefit that is more substantial compared to the sum of benefit coming from each individual that acting by oneself. Thus, the wider symbiosis network is, the more benefit reaped from a better functioning PCS.

In the IS literature, three different mechanism on how IS develops are including self-organisation, facilitated and planned (Baas & Boons, 2004; Chertow, 2007; Gibbs & Deutz, 2007; Hewes & Lyons, 2008; Paquin & Howard-Grenville, 2009; Chertow & Ehrenfeld, 2012). Chertow (2007) provides an explanation of self-organising and planned symbiosis. Self-organising emerges from two or more private companies that already started the exchange and once the interaction and benefit are uncovered, it will require coordinators to organize and scaling up the network. On the contrary, planned symbiosis takes a top-down approach following a government initiative to build the system from the scratch (e.g. deciding the site and identifying various companies to be located together). Facilitated symbiosis is a mid-point between self-organised and planned-symbiosis, where coordinators will be needed to bring firms together in creating network due to lack of knowledge, experience or connection with other interested firms (Paquin & Howard-Grenville, 2009). Facilitators can be a person, private firm or public body.

In the context of PCS implementation, two mechanism of symbiosis development, namely self-organised and facilitated symbiosis, will be studied. These two mechanisms are suited well with PCS implementation because PCM has always built some degree of network on exchange or it has willingness to build a necessary network but lacking capability to proceed.

3.1 Industrial symbiosis network development

Researchers (e.g. Baas & Boons, 2004; Chertow, 2007; Doménech & Davies, 2011; Chertow & Ehrenfeld, 2012) have studied assorted IS and conceptualized the stages of IS development. Some part of those studies can be used as an analogy in PCS network development. Doménech & Davies (2011) studied three different IS and deduced that in general IS development consist of emergence, probation, development and expansion. In the emergence stage of IS development, some firms may already have some form of exchange that occur spontaneously or facilitated. The emergence can result from constraints faced by firms, realising opportunity for vertical integration. In the second stage, probation, firms are aware by the dynamic of the network and have more knowledge resulting from the experience and feedback in the first stage. Positive experience and feedback bring about trust that will preserve the network. Probation is a crucial phase that determines the continuation or failure in IS. In the development and expansion, the network will grow wider and deeper. More interaction provides more knowledge, trust and opportunity.

Study on self-organising IS proposes the development of an IS network following three stages: sprouting, uncovering, embeddedness and institutionalisation (Chertow & Ehrenfeld, 2012). Sprouting is indicated by the exchange occuring between firms randomly and may be followed by others if there is mutual interest and the existing example is proven to be successful. Uncovering is a result from observation by other actors outside the transactional network who recognise the benefit of exchange. Embeddedness and institutionalisation are intentional expansion and development in the network that resulted from trust in the earlier stage.

Baas & Boons (2004) studied the possible phases in facilitated symbiosis using Rotterdam harbour as a case study. The first phase, regional efficiency, involving independent decision making by firms and collaboration between some of the firms. Third parties may facilitate this process. This was followed by regional learning in which wider exchange occurs, based on the trust built in the first phase resulting broader network. The third phase is sustainable industrial district where actors develop a vision on sustainability and act upon it.

3.2 Symbiosis network trajectories

According to Kilduff and Tsai (2003), a network evolves over time and changes following certain trajectories of goal-oriented process or serendipitous process. In the goal-oriented trajectory, the network can be formed because of the established common goal and it will require a facilitator to bring actors together and coordinate their activities. The development of this type of network will be relatively fast because of the role of facilitator but may not be as stable if the collective goal is not attained. In the serendipitous network, there is no particular goal and the initial interaction often occur just by chance. This type of network takes relatively long time to develop but tend to be more resilient because of the trust and likeness created in the initial phase (Gulati & Gargiulo, 1999; Uzzi, 1996).

These two networks process can develop independently as an exclusive trajectory or can integrate to become a mixed trajectory. In independent serendipitous process found in self-organizing IS, the symbiosis started by happenstance and is proven to be more successful in the long run (Chertow, 2004). The successful future of this symbiosis is caused by trust gained from experience in the initial exchange.

In the independent facilitated IS, the network process is more goal-oriented, where the collective is formulated initially and a body is appointed to facilitate interaction among firms. Although this type of network is more prone to a failure, proper management has proven that a goal-oriented network can flourish and be long-lasting. An example comes from facilitated IS in the UK (Paquin & Howard-Grenville, 2009). The key success of this network is the attainment of collective goals. Once the collective goals are achieved, a revision to maintain the network becomes necessary.

When serendipitous and goal-oriented networks are not completely exclusive, mixed trajectory occurs. Self-organised IS can take a mixed course of network trajectories. It starts with serendipitous process where random exchange that occurs between firms that recognise opportunity. This exchange will continue if they happen to gain mutual benefit and can trust each other. Once actors outside this initial network recognise the benefit that they may obtain, while others may join the network and anchor tenant can emerge. This anchor tenant not only acts as the main driver in the exchange but also as an organizer for the network. Following this course, a more goal-oriented trajectory will emerge. The interaction and exchange will be organized and possible collective goals will be pursued.

4. PCS network development

Although various studies emphasize the importance of PCS implementation to improve overall supply chain, there is only study on the network build mechanism in establishing PCS. Srour et al. (2008) utilised a framework from deployment process of information system to study the best practice of successful PCS implementation by applying the framework into various IOS. The study took stance from a technical point of view where PCS implementation followed four stages: project initiation, system analysis and design, implementation and adoption, maintenance and growth.

Another study analysed focal organisation as the key for successful PCS implementation through leadership and promotion of PCS benefits (MED-PCS Project, 2013). The study identified three types of focal organisation including national or regional government, private firms, and port authority. The first type, national or regional government, will promote business-to-government activity in which their direct contribution is limited to financing PCS start-up. Instead, they will push PCS implementation through regulations. The second type of focal organisation is private firms that follow a bottom-up approach. They demand PCS because a complex ports procedure requires advanced information technology (IT) solutions and vertical/horizontal integration. This integration will involve various parties in different stages of particular the supply chain (vertical integration) and various companies will belong to same sector or market (horizontal integration) (van de Voorde & Vanelslander, 2009). The last type follows a top-down approach provided by the port authority. Private involvement can be voluntarily or obligatory. The former scheme allowing operators to adapt the system or continue to use a conventional paper-based system, the latter one will require operators to adapt PCS system as a required condition to use ports facility.

Previous works on identification of the stages in PCS implementation took the course of a goal-oriented trajectory. Project initiation started by formulating collective goals to achieve by applying a PCS-like system (Srour et al., 2008). This type of work will require a facilitator either from the government, private body or port authority (MED-PCS Project, 2013). In this case, goal-oriented trajectories are seen to be applicable because of the urgency of PCS implementation. A goal-oriented trajectory is expected to accelerate PCS implementation by identifying the problem and goals purposely and increasing participation of PCM by informing and bringing together as many actors as possible. Facilitators will not only coordinate and organize various actors and activities needed to attain collective goals, but they will also reap benefits due to its certain position if they are not independent parties. Facilitators that also part of the PCM will have better understanding on the current situation but may steer a goal formulation or decision that will favour toward their own interest. On the other hand, if facilitators are an independent party outside PCM, they will be more neutral toward equal collective goals but may have limitations on the understanding of the existing situation.

4.1 Phases of PCS network development

Based on the lesson learned from IS development and symbiosis network trajectory, this chapter considers how a network development mechanism for PCS implementation is formulated. Instead of formulating the development as top-down or bottom-up, network trajectories theory is used, and the role of facilitators is acknowledged regardless of their position related to PCM (e.g. private firm, port authority, independent party). This type of formulation will result in a bigger picture on network development in PCS that is expected to contribute to the knowledge development on the best practice in PCS implementation.

The mix trajectory is seen to be the most proper network development for PCS following the stages of pre-PCS network, PCS network emergence and PCS network expansion. A previous study that suggested the work on PCS development starts with goal formulation did not emphasise sufficiently the existing network as the precursor of PCS network.

4.1.1 Pre-PCS network

Inter-organisational network occurs naturally in many sectors due to the lack of certain resource that can be filled by others. In the maritime supply chain, the lack of certain resource is caused by the complexity of that supply chain that can lead to inefficient moving of goods from one point to another. This complexity creates specialisation from each actor along the supply chain to handle certain issues. Multiple network are then formed from the transaction of multiple actors in which each actor can be in more than one network, or move from one network to another, until mutual gain is realised. This type of network formation is mainly serendipitous with the absence of network strategies. Each actor acts on behalf of itself independently to create a connection with others

This network process tends to be realised based on the potential gains of working together. Actors will decide with whom to work based on the information about other actors or personal relations between key persons in different firms. Trust and likeness are built once the collaboration turns out to be fruitful, leading to more openness toward information exchange. It is illustrated by an example from Johnson & Styhre (2015). In certain ports, the cargo owner will be required to work with a specific agent. Some agents may have a personal preference on a certain shipping company and provide information exclusively. This occurs when multiple vessels approach a temporarily congested port and an agent will share this information to selected a vessel so that the vessel can speed up and arrive in a timely manner to be served.

Every actor in the network will expect a stable long lasting partnership built on trust (Dore, 1983). By maintaining a stable relationship, it will reduce the search cost spent in the attempt to find other reliable actors to replace older ones (Chertow & Ehrenfeld, 2012), and also reduce risk from working with unknown new actors. For example, another stevedore company may use different equipment to unload cargo efficiently resulting in a shorter ship turnaround time. When a long lasting partnership is preferred and trust has been built, a shipping company will not just end the contract and use another company; the shipping line will discuss the matter and even offer help the stevedore to improve their work.

This serendipitous trajectory will lead to multiple dense clustering networks built by multiple supply chain in which all actors connect to one or more other actors inside and outside particular network. The fact that one actor may be involved in multiple networks may help other actors to grow their network based on the referral.

4.1.2 PCS network emergence

Based on the work of Kilduff & Tsai (2003), the last stage on a serendipitous trajectory is the emergence of brokers. This occurs because of the weak tie between one cluster network with another that causes the active member in each cluster network to reach out and enable the exchange across the network. The emergence of the broker is the beginning of the goal-oriented trajectory in the PCS development stage. Broker/focal organisation/facilitator is usually the one who recognises the necessity of PCS, or the one that is responsible for system change due to the legislation. The type of facilitator depends as well on the size of the port and its primary activities. Big ports usually host various private operators who may take a role as facilitator in PCS implementation (MED-PCS Project, 2013). Alternatively, government may facilitate in big ports too when their primary activity is trading and they have to handle a lot of custom related issues. In the absence of a natural candidate, the port authority can take the responsibility as facilitator.

As PCS project initiation begins, formulating strategic vision containing problems formulation and collective goals is a priority (Srour et al., 2008). In the presence of many actors in big ports, it may be more difficult to achieve a common vision and value. Problem formulation can be difficult due to the actors' heterogeneity resulting in a heterogenic result on what is the most urgent problem to address. Therefore, the facilitator is required to identify the existing network and its dynamic, existing exchange, how the current exchange is conducted, and the experience and feedback from those process. That information will be the starting point for starting the conversation on strategic vision formulation. Then, in order to attract an interest of PCM toward PCS implementation, the facilitator will be collecting and communicating information about the potential improvement from PCS implementation, data security issues, examples from other ports, and regulations that may and may not support the implementation. It is also important to reach key person(s) in every network in the attempt to convince PCM; later on, those key person(s) are the ones who will deliver the message into their own network. Next, the facilitator can provide a space/platform for actors who develop early interest on PCS to communicate and exchange ideas or information. A goal-oriented network is sensitive to the coherence of the collective goals, and conflicts about them can cause the network to fail (Kilduff & Tsai, 2003). The management scheme is another important issue to discuss early in this stage once PCS is successfully implemented. Experience shows that management issues are considered important in the success of PCS implementation around the world; some even stating that PCS implementation is not technological change but "change management project" and emphasise issues related to management change such as pilot user involvement, user training, dissemination with regards to PCS development (IAPH, 2011).

Following project initiation is system analysis and design, then implementation and adoption (Srour et al., 2008). Although this phase seems to be technical due to the design development of the PCS, the more important factor is assessing the functionality needed by the prospective users, based on the collected information in the previous phase. The functionality must provide the users with what they need. Functionality risk is considerably high in the IT system improvement, due to system designers who could not capture users needs or the evolution of needs over time (Clemons, Thatcher, & Row, 1995). System designers of PCS may face problems when there is a significant disagreement among prospective users related to the system functionality and requirements. Although the majority of ports do not outsource their technology development orr data centre and telecom operators (IAPH, 2011), reaching outside resources is a possible option to fill the gaps or supplement their work, as what has been done by few ports is a common trajectory in the network-oriented goal (Kilduff & Tsai, 2003). An important aspect is supervision from the port authority if the work is outsourced, so the results will comply with the legal requirement of multiple government bodies to whom the port are responsible. Pilot testing with pilot users will be followed in the procedure in order to have first-hand experience of the system and provide feedback for the system evaluation. Pilot users are usually the major stakeholders in the PCM, thus this testing aims as well to incorporate the information from key activities in ports.

The primary challenges in this stage are collective goals formulation and system acceptance. The difficulty in collective goals formulation is caused by actors' heterogeneity, leading to unclear vision toward the urgency and benefit of PCS implementation. If the major actors happened to be the facilitator, they may subtly direct the goal toward their own interest or even impose it. Caution needs to be taken if collective agreement could not be reached because it may lead to groups forming that will push forward their own collective goals. Another challenge in bringing stakeholders together to formulate collective goals is rooted too from the serendipitous process proceeding PCS network emergence. The serendipitous trajectory will create a clustering network that has tight ties between members in a particular network but weak ties across networks (Kilduff & Tsai, 2003). Even though a goal-oriented network has a distinctive trajectory, the outcome of the two similar type of networks can be different due to their sensitive nature to the initial condition (Kilduff & Tsai, 2003). This is illustrated by examples of how the initial financing scheme could affect the continuation of PCS-like system in Port of Rotterdam and America (Srour et al., 2008; MED-PCS Project, 2013).

System acceptance is another major challenge. Implementing successful PCS will require incremental technology improvement compared with the current system. Srour et al. (2008) emphasised the importance of resemblance between the existing system and the new system. This is because the users are used to a typical system and radical change only makes them lose trust in the new system. They do not see it as simplification of current system instead it will be perceived as ports' way to shift their responsibility toward customers. That is why the modular approach in PCS is seen as a key factor to the acceptance of PCS implementation. The modular approach will incrementally improve the PCS functionality without creating extreme change and sthat help with the users' acceptance. Moreover, it will also avoid information inundation to the users, since the module will serve a specific purpose. This specific purpose will also ease the evaluation process in assessing the system benefits or shortcomings in order to make further improvements.

Another issue related system acceptance is caused by the information transparency provided by PCS that can reduce the benefit reaped by certain port community member, namely ship owners. Presently, one of the most crucial issues due to lack of transparency is the long idling period of ships' operations. Ships may need to stay at anchor for days before getting to a berth under the conventional first-come first-served (FCFS) basis. This could be solved by applying just-in-time (JIT) operations under PCS, in which incoming ships will receive the latest information about departing time of the ships that are already on berth, and where dynamic berth slot planning is applied instead of FCFS. The incoming ships may need to switch to slow steam in order to adjust to the new available berthing schedule. Slow steam and shorter idling period will produce environmental and economic benefit due to fuel saving.

Nevertheless, challenges persist because it will disrupt the system legacy, change how all operators should work, and reduce important revenue coming from demurrage. Demurrage is a compensation paid by charterers to ship owners when they cannot load or unload cargo within certain period of time that has been agreed contractually. This contractual agreement provides no incentive for ship owners to implement JIT operation; conversely, steam at full speed to arrive quickly to start the laytime period is an attractive option. Thus, a new commercial contractual framework that reassures fair share of benefits between charterers and ship owners is important to support this stage. Transparency will also prevent favoritism, since necessary information will be distributed fairly and prevent illegal activity such as bribery (Keceli, Choi, & Park, 2007).

4.1.3 PCS network expansion

PCS development does not stop once the system is implemented and early adopters start utilising the system. Constant work will need to be carried out including maintaining and expanding the system and the network. Collective goals needs to be assessed and certain actions must be taken, weather the goals are achieved or not, because the network of a goal-oriented trajectory can collapse either when the collective goals are not achieved or have been achieved (Kilduff & Tsai, 2003). The former means failure while the latter implies that there is nothing more to be done. Although PCS can achieve its collective goals, functional risk remains due to the dynamic needs of the users. Therefore, new goals need to be invented and a perpetual system improvement is required. On the other side, achieving collective goals will help the network to be more stable among the users, by providing reassurance that the system works and benefit the users. It will create more trust, leading to willingness to implement innovation that is riskier. PCS success will attract actors who are still outside the system to join, especially through referral. When more actors join, PCS will increase the accuracy on processing the information, the reutilisation of information and the quality of information services (Srour et al., 2008), which provides more proof and assurance in using PCS and creating a positive feedback regarding adoption level of PCS. Naturally, more actors will join voluntarily once the system is stable and widely used because it will leave the actors outside the network with no option to access information their need unless they are in the inside the network.

PCS network expansion occurs when new actors join a certain network or multiple PCS across different ports are being connected. . Connecting multiple well-established PCS can be a new collective goal from a new wider network comprising inter-PCM. Technology advancement is vital to deal with massive information flows, message standardisation and to contain higher security issues. Nevertheless, PCS integration is a problematic issue because there is competition among ports; therefore a proper coopetition strategy is required before this can be realised.

4.2 Determinant factors in PCS development

Each different stage of PCS network development has its own determining aspects that can act as barriers as well. Those determining aspects are categorised into social, economy, technology and regulations. Table 1 shows the summary and main characteristics of PCS network development including where the deployment stages proposed by Srour et al. (2008) are situated in the network and also the main determination in different stage of the network development. The determining aspect is categorised based on its importance in each of development stages. Although all determining aspects play a role in every stage, the degree of importance is different.

Table 1 Summary and characteristics of PCS network development

	Pre-PCS network	PCS network emergence	PCS network expansion
Network trajectory	Serendipitous • No collective goals • Based on potential mutual gain • Continuation based on trust and likeness • Slower to develop but more resilient	Beginning of goal-oriented • Facilitator is important • Collective goals formulation • Quicker to develop but less resilient	Goal-oriented • Constant reinvention of collective goals • Long experience deepen trust • Willing to implement more risky innovation
Challenges	• Strong sense solidarity intra-network may lead to hostility across network • Favouritism	• Collective goals formulation • System acceptance	• Constant evolve in defining new collective goals and improving system • Inter-port PCS connection
Determining aspects	Social, regulations	Regulations, economy, technology	Regulations. economy, technology
PCS deployment stages (Srour et al., 2008)		• Project initiation • System analysis and design • Implementation and adoption	• Maintenance and growth

Regulations play an important role throughout the stages of PCS network development. At the regional level in Europe, it is shown by EU Directive 2010/65 that aims to harmonise and simplify administrative procedures in maritime transport through information exchange standardisation. PCS development is not always pushed by regulations that specifically targets IT system in a ports administration process. Other regulations, such as environmental standards on air emission, require a vessel to reduce its emissions. One of the methods to reduce air emission is achieved by reducing vessel speed, especially when ports are congested. This real time and transparent information is only possible to acquire from a PCS-like system. On the other hand, regulations can hinder PCS implementation in the case of the obligation to present certain document in hard copy form or invalidity of a digital signature. Regulations become prominently important in PCS network expansion if two or more PCS system will be integrated across ports, since the PCS utilisation can be country specific especially from a customs perspective.

The social aspect of how the relations between individuals or organisations could develop is the basis of how a serendipitous network is built. It usually exhibits certain characteristics such as the absence of complex technology advancement or transformation; instead social aspects such as cross-communication and interaction will be crucial as a foundation for the partnership. Instead technology and economy aspects come hand in hand since technological advancement will require financial investment.

Financial investment becomes a burden for certain actors. Small firms with limited resources and activities will not see the benefit of joining PCS compared to bigger firms that have a bigger share activity in a port. Thus, cost structuring in PCS will increase the success rate of PCS adoption. In the port of Rotterdam, two cost schemes exist: subscription fee plus payment per transaction, and a slightly higher payment per transaction (MED-PCS Project, 2013). Bigger users, with more financial capability, will choose the first scheme because it will create benefits from a lower fee per transaction, on the other hand, less-frequent users can opt for the second scheme, creating a win-win solution for different users. Government subsidies can also ensure more adoption of PCS by financing PCS development e.g. ports of Rotterdam and Hamburg (MED-PCS Project, 2013).

Technology determines whether PCS network emergence and PCS network expansion will be successful or not. This aspect is not about applying the most sophisticated technology; instead, it is about capturing the users' needs, user friendliness, and compliance with local/national regulations. One of the reasons of PCS-like early implementation in port Kumport failed was caused by software incompatibility that was developed by a foreign company and did not comply with public body requirements (Keceli et al., 2007).

5. Conclusions

Based on IS development and network trajectories theory, this chapter conceptualises the evolution of PCS network development into three stages: pre-PCS network; PCS network emergence; and PCS network expansion. The difficulty on PCS implementation is due to its complex nature and intermeshing aspects on social, economy, technology and regulations. This study shows that PCS implementation is beyond technological implementation; it instead has a strong social side in understanding where the network comes from and convincing various actors to use technology that, to some extent, has abstract and even unequal benefit. Having an understanding of the prevalence of each stage will help related actors to comprehend the dynamic process that occurs and to take precautionary actions in every stage in order to implement PCS successfully.

These findings are expected to help accelerating a port's sustainability transition agenda through the adoption of inter-organisational information system, since sustainability shall be achieved through a holistic approach and a vision to the future. Yet, many questions still remain and need to be answered, because scholarly studies on PCS itself are still very limited. Many directions need exploration, including the environmental and economic benefit of PCS, PCS implementation and ports competitiveness, and case studies on PCS network development. As a future direction, network development can also be explored on how to expand PCS network for integration across ports.

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