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Port Inter-Organizational Information Systems: Capabilities to Service Global Supply Chains

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Abstract

This paper provides insights into the ways global sea ports are challenged by the need for managing complex information flows, given the developments in global supply chains. We argue that special port IT capabilities are needed to address these challenges by sharing information and planning and executing container transport in a collaborative way, establishing inter-organizational information architectures, and coordinating interests to successfully implement the technological infrastructures. We focus on the role of port community systems that support port communities in meeting the demands of global supply chains.

Foreword

This monograph aims at providing insights into the ways global seaports are challenged by the need for managing complex information flows, given the developments in global supply chains. We argue that special port IT capabilities are needed to address these challenges by sharing information and planning and executing container transport in a collaborative way, establishing inter-organizational information architectures, and coordinating interests to successfully implement the technological infrastructures. We focus on the role of port community systems that support port communities in meeting the demands of global supply chains.

This monograph has a multidisciplinary nature and should be of interest to students, researchers, and practitioners in several fields, including information management, information systems, operations management, supply chain management, and technology management. This monograph combines a number of chapters where concepts are explained, while referring to a large repository of case studies provided in an appendix. Also, an introduction to the container transport network is provided in an appendix.

We sincerely thank our co-authors Marcel van Oosterhout, Jordan Srour, Albert Veenstra, Hans Moonen, and Rommert Dekker, for helping us to establish this monograph. Each chapter indicates the authors that contributed the most, but some authors have made contributions to almost all of the chapters and appendices.

In addition, we thank our industrial partners in providing us with valuable data through interviews and documentation in order to arrive at the case material provided in Appendix B. The industrial partners are Port Infolink, the port authorities of Rotterdam, Hamburg, Singapore, and New York and New Jersey, INITI8, the companies involved in the case on Vos Logistics, and Science Applications International Corporation.

Student Eric Giljam has helped us with the preliminary versions of the written material, while student Tycho Roksnoer helped us assembling the reference list.

Peter van Baalen, Rob Zuidwijk,
and Jo van Nunen

Contents

1

Introduction

Peter van Baalen and Rob Zuidwijk

This monograph discusses three IT capabilities that ports are developing in order to address the challenges of global networks. This monograph focuses on the global transport of containers, so the introductory chapter starts in Section 1.1 with a short exposition on the adoption of the maritime container standard. We explain how this standard has enabled the development of intermodal transportation networks in which ports are hubs in Section 1.2. In Section 1.3, we highlight important developments in global supply chains that challenge the competitive position of ports and in Section 1.4, we discuss the role of IT as an enabler. In particular, we discuss in Section 1.5 how ports could develop three IT capabilities to address these challenges. We consider the question how Port Community Systems (PCS) may contribute in Section 1.6. In Section 1.7, we describe the objectives and set-up of this monograph.

1.1 Setting the Stage: Adoption of the Maritime Container Standard

On April 26th, 1956, Malcolm McLean loaded a converted T-2 tanker named ‘Ideal-X’ with 58 35-feet containers on its specially modified decks and sailed from Newark, New Jersey to Houston, Texas [94]. This was the start of one of the most important and far-reaching innovations in transportation around the globe. Sea-Land, founded in 1966, was the first to launch transatlantic containership operations. Other transatlantic carriers did not realize the advantages of container transport yet. Some of them experimented by placing containers on decks of general cargo ships, whereas others made only slight adjustments to their vessels. The severe investment costs involved were, for most ocean carriers, a reason to ignore the rise of containers in the initial stage, although the replacement of break-bulk by containers reduced shipping costs extensively. The problems in this stage were the load and size differences in various countries and the varying customs approaches to container clearance. After the enormous success of Sea-Land, various other carriers from across the world joined in the success of the transatlantic container business [108].

The next step in the evolution of the container business was the standardization of the container, which was needed for the container handling equipment. After several rounds of negotiations in the 1960s, the agreement was made to use the $40 \times 8 \times 8.5$ foot^3 container as the standard, which is the equivalent of two Twenty feet Equivalent Unit containers (TEU). The supply of the US forces in Vietnam convinced the world of the potential of the container [94].

During the 1980s, container carriers started to compete with each other exploiting economies of scale, and as a result, container vessels began to grow by means of size and length. Before this moment, vessels could only carry around 100 containers. The fierce competition led to container vessel growth in increments of 1,000 TEU, and present-day container vessels can carry more than 12,000 TEU.

The adoption of the standardized container has resulted in more efficient handling of cargo during transport and transshipment [108]. In particular, it enabled intermodal transport, i.e., the movement of containers from point of origin to point of delivery using different modes of transport, such as ships, trains, and trucks, without handling the goods themselves during transshipment. Intermodal transportation aims at the transfer of goods in a continuous flow through the entire transport chain [71]. A seamless connection between the container transshipment points in ports and the intermodal networks of rail, road, and rivers and canals is a requirement to achieve this.

1.2 The Network: Ports as Hubs in Global Supply Chains

Reduced costs of intercontinental transportation enabled industries to globalize their operations, and to locate production facilities at those places in the world where conditions are favorable, not necessarily close to the markets. As a consequence, the various supply chain activities are performed in different parts of the world.

Global supply chains are actually complex networks, which consist of many different stakeholders, including shippers, deep-sea carriers, port operators, and customs organizations; see Appendix A for a description of the most important organizations in these networks. Global supply chains also constitute trade lanes in which commercial transactions take place. In most commercial relationships, a wide range of intermediary and agency services will be used to enable the transactions, adding further complexity to the network. Moreover, the form and shape of a supply chain within the network can vary from one transaction (shipment) to the other [74].

Seaports, to which we plainly refer as "ports" from now on, constitute the links in global supply chains at geographical, political, and commercial boundaries. Ports provide the opportunity as physical hubs in the network to connect large intercontinental good flows to more distributed regional distribution networks. As such, the role of ports in global networks has traditionally been defined by its interface function between maritime and inland transport. According to Carbone and De Martino [25], their role has been dramatically changed into the management and coordination of material, financial, and information flows within global supply chains. In particular, Veenstra [167] argues that ports can be positioned at three different levels in global networks. First of all, ports are transshipment points in the transportation network. Second, ports have developed into logistic centers, where cargo is not only transshipped, but also transformed, customized, finished, and re-packaged. In this manner, ports facilitate adding value activities in the logistics network. To support this, container freight stations and

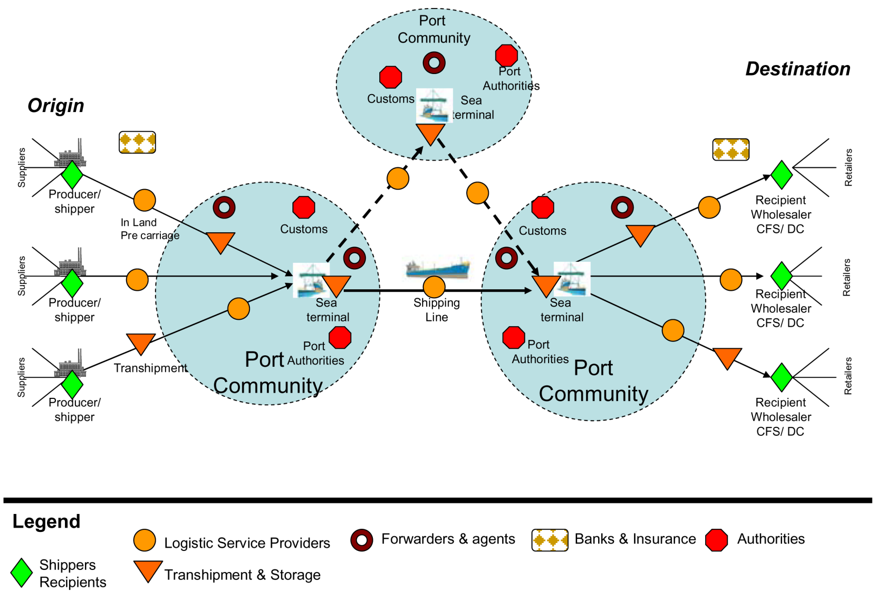

Fig. 1.1 Embedding of ports in global networks.

distribution centers are built on, or close to, the transshipment terminals. Third, some ports have attracted much more than just logistics activities by accommodating industrial activities within the port area. At this level, ports host a variety of functions in the global network.

The embedding of ports in global networks, as depicted in Figure 1.1, also implies that the port's prosperity is, to a large extent, determined by developments in global supply chains which are beyond the control of port management [65]. In the next section, we highlight a number of these developments and their impacts on ports.

1.3 Ports and Supply Chains: A Global Competitive Environment

In this section, we briefly discuss a number of important developments that affect global supply chains and, as a result, have an impact on ports. These developments include globalization, outsourcing, economic change, sustainability, and safety and security.

1.3.1 Globalization: Impacts on Container Transport Volumes

The world is moving persistently toward a single, global market. Purchasing, production, and distribution to the markets take place where the greatest benefits can be achieved. Trends, such as the increasing scale of operations, specialization, and customer-oriented production, proceed relentlessly. Due to commoditization, containerization, and economies of scale, transport costs are in decline. As a result, worldwide transport flows have grown spectacularly in the last two decades [156]. Recent developments on the financial markets have caused a decline, but in any case, container transport volumes are connected with the global economy.

Furthermore, the dynamics in shipping and port development are progressively impacted by the globalization of supply chains, because businesses are operating on a global scale and demand a global service package. Shippers prefer to negotiate global contracts with a few global service providers, instead of having to deal with a multitude of local players. In particular, regional ties become weaker, so that competition between ports intensifies. On the other hand, port operators act progressively on a global scale in order to face the large shipping lines [111].

1.3.2 Logistics Outsourcing: Demand for Operational Excellence

Globalization and specialization in global supply chains has resulted in outsourcing of logistics services such as transportation, transshipment, storage, and forwarding. The organizations that execute these activities experience an increasing pressure on logistics performance in terms of timely delivery and system-wide inventory costs [64]. Although economies of scale, by means of the use of larger container vessel sizes or the management of a large intermodal network, help address these demands, innovative and complex inventory strategies are required to manage centralized, decentralized, and moving stock. Moreover, management of global supply chains moves from supply focus to demand focus, in order to meet a diversifying demand for products and services.

Just in time delivery concepts force all activities throughout the supply chain to be synchronized, and to be planned and executed in a collaborative way [150]. In such a context, however, there are also many opportunities to provide value adding logistics services [72].

For the ports, there is a need to offer port and terminal capacity to handle large vessels and large call sizes. Ports have the opportunity to act as main hubs by offering efficient handling of large container volumes with good hinterland connections to the regional markets. In addition, ports can develop distribution centers in which value adding logistics and distribution activities can be deployed.

1.3.3 Emerging Markets: The Hinterlands Redefined

Economic activities change as regions e.g., develop production capacity or host emerging markets. For example, in the European Union, the emerging economies in Eastern Europe triggered new good flows. However, recent economic developments have had a considerable negative effect on these economies [23].

For European ports, these developments require the periodic redesign of the connecting intermodal networks to hinterland destinations. Similar developments can be observed in other regions in the world.

1.3.4 Sustainability: Greater Concern for the Environment and Society

Industry is progressively confronted with the impacts of its activities on the natural and social environments. First, scarcity of public resources, such as space, transport infrastructure capacity, and accessibility of commercial and populated areas, is affecting the performance of the distribution networks. Second, as certain virgin materials are scarce or expensive, industry is progressively considering material recovery through recycling as a substantial sourcing alternative [54]. On the other hand, industry is also triggered to accept their environmental and social responsibilities through pressure from external stakeholders. A growing number of governments are regulating the environmental and social impacts of industrial activity, and non-governmental organizations are creating awareness of the general public. As a consequence, social responsibility is firmly taking root, and commercial organizations are accounting their social and environmental performance, next to their financial performance.

Ports face the challenges mentioned to the full extent. First of all, ports are usually situated in the vicinity of densely populated areas, and are confronted with competing demand of space and infrastructure; space can be allocated to host distribution centers or transshipment terminals, but this may be in conflict with city development. In order to maintain accessibility of populated areas, road transport may be limited in the use of the road network. Moreover, environmental legislation may limit the amount of transport and logistics activities in designated areas.

1.3.5 Safety and Security: The Rise of Control Mechanisms

Another important public interest, safety and security, has forced global supply chain management to create guarantees and control aimed at the mitigation, prevention, and resolution of compromised food quality, terrorism, and general crime risks. In addition, even more attention is being devoted to the prevention of disasters involving dangerous goods, i.e., external safety. In this respect, supply chains are confronted with increased control and administrative requirements [79].

International initiatives, such as the IMO International Ship and Port Facility Security (ISPS) Code, and the American Maritime Transportation Security Act of 2002, are having a significant impact on ports. Moreover, port security and supply chain security cannot be considered separately.

1.3.6 Competitive Position of Ports: Main Challenges

Their unique geographical locations served ports as the basis for global competition [55]. Although location is still an important source of the competitive strength of ports, other factors are determining the competitiveness of ports as well. Factors that appear to be important are: proximity of selling markets, multimodal linkages, efficiency of road networks, labor costs, labor flexibility, space, land costs, quality of working place, and information supply [161]. However, the importance of these location characteristics in the global competition between ports is only relative to the role ports can play in global supply chains. Considering this new role of ports, it becomes clear that ports no longer compete solely on the basis of location characteristics, but on the value they add and the services they can provide to global networks [155]. Moreover, hosting economic clusters or ecosystems, i.e., concentrations of related economic activities, such as durable energy, or the chemical industry, constitute a possible competitive advantage as well.

The shipping lines vertically integrated, backward and forward, larger parts of the logistic chain to exert power in the globalizing transportation system. Total transport costs in the logistics chain became the key consideration in selecting the number of ports of call [155]. The main implication for ports is that a shift of focus has taken place from the traditional port-to-port service, to a focus on an integrated logistics chain. This fundamental change in the global transportation system has induced ports to play another, more active role. As territorial characteristics, especially connection to the hinterland, have become less important, the source of the port's competitive advantage has shifted toward facilitating cargo control. Hayuth [71] explicitly states that "whoever controls the cargo throughout the entire intermodal system has the competitive edge over anyone who exercises control in but single transport modes". Containerization, intermodal transport, and the embedding of ports in global networks have increased the importance of the role of information dramatically.

We may summarize that developments, such as globalization, liberalization of trade, outsourcing of logistics, endorsed by the rise of new information and communication technologies, have induced increased puzzlement and uncertainty about the role of ports [124]. Ports are not just a point of transfer between land and sea. Instead, ports have become complex, intermodal, and multipart systems in which institutions and functions often intersect at various levels [13]. Moreover, they are embedded in global supply chains in which they are expected to add value and services to these networks. At the same time ports are spatial, logistical, financial, and informational hubs that serve the interests of geographical regions and nation states. They compete with other global ports on the basis of uniqueness of location, services, functionalities, administrative regulations, etc. Ports are thus bounded and unbounded to geographical space. In both modes, flows of information increase rapidly in terms of volume and complexity. These inter-organizational flows of information are increasingly supported by advanced port community systems.

1.4 IT As an Enabler

Information Technology (IT) has been an important enabler for the development of global supply chains. The development of international IT networks, complex ERP systems, and specific supply chain IT solutions has enabled a fundamental redesign of supply chain processes [81, 163]. With supply chain management systems, companies would be able to track and trace the exact position of their products in the production and distribution chain, determine the current and expected inventory levels, and the required transport movements to get the right products at the right assembly location at the right moment. Moreover, information and communication technologies have enabled the execution of geographically dispersed logistics and production chains and the support of different models for chain planning and control, with different roles for the involved stakeholders such as producers, forwarders, brokers, transport operators, warehouse operators, consultants, and financial service providers [170].

Also for ports, IT has been an important enabler to support automation of physical activities and provide an information infrastructure and platform required to handle large volumes of information that accompany the maritime transport of goods and especially containers. We discuss information and coordination issues and requirements in container transport in more detail in Section 2.6. We now reflect on the enabling role of information systems as a means to make decisions in a systematic way and the use of information to create a competitive edge.

1.4.1 Decision Support Models in Container Transport

Decisions in container transport are concerned with the design, planning, and execution of transport systems and can be supported by the use of formal models that can be implemented in (inter-organizational) systems. Before we explain in more detail how information is an enabler in global supply chains and in ports, we briefly discuss the use of modeling techniques in this context. This brief overview is far from exhaustive and reference is made to comprehensive reviews already present in the literature.

As Macharis and Bontekoning [96] point out in their survey, intermodal transport holds a lot of opportunities for Operations Research. They discuss the literature based on the type of operator involved in the supply chain and the time horizon of the decisions at hand. In their review on intermodal transport, Crainic and Kim [38] use a similar categorization. Along the same lines, we shall consider: drayage, the terminal, the network, and the intermodal services on the networks. We will also distinguish strategic, tactical, and operational decisions.

Drayage concerns the pick-up and delivery of containers by trucks between the port terminals and the shipper (consigner or consignee) locations in the hinterland. The process is characterized by relatively high costs and uncertainties due to, amongst others, the complicated release process of the containers at the terminal. Models that have been developed are on-line variants of the vehicle routing problem; see for example [119]. Máhr et al. [97] discuss the drayage problem, and review and compare operations research approaches and agent-based approaches. It turns out that the arrival pattern of the order information, i.e., the points in time it is known when the containers are released and ready for pick-up, plays a decisive role here. Besides planning and execution, strategic decision-making in this context, as Macharis and Bontekoning [96] point out, could refer to long-term collaboration between carriers in coordinating pick-ups and deliveries.

The complexities and uncertainties associated with the planning of terminal visits by barges have recently received attention in [45, 46]. Here also, an agent-based approach has been advocated, mainly justified by the fact that many independent organizations are involved.

The review papers [141, 142, 171] provide excellent insights into the vast literature on modeling approaches in the design of container terminals, and the planning and execution of terminal operations. Steenken et al. [142] discuss the literature along the main planning and execution processes. The waterside transshipment process involves the allocation of berths to ships, the stowage planning, i.e., the positioning of containers on the ship taking into account the loading and unloading at a sequence of ports, and the scheduling of cranes to ensure the efficiency of the loading and unloading processes. As a buffer between waterside and landside operations, containers are usually stored in stacks, which also needs to be planned in order to avoid unnecessary moves. The internal transport between the waterside and the stacks requires rigorous planning, especially when executed by Automated Guided Vehicles [171]. In general, the planning and execution problems are characterized by the specific equipment used on the terminal [142]. The landside operations at the terminal concern the transshipment between the container stacks and the various modes of transport to the hinterland. The methods that support planning and execution may also provide parameters to support the design of container terminals [102, 171].

The design, planning, and execution of hinterland transport involve the design of transport networks and the development of intermodal services on and between those networks. As indicated in for example [36], the design of an intermodal network can be supported by the solving a multi-commodity network design problem, where transport capacities and flows on legs in the network are established against minimum cost while meeting demand. The design of services on the network comes down to the specification of routes in the network and (scheduled) arrivals and departures at stops along these routes. The services are usually defined in such a way that consolidation between main hubs in a hub-and-spoke network can be achieved while maintaining a certain frequency. The services may address additional customer requirements such as the use of a specific transport mode or quality of the service. Crainic [36] presents modeling approaches of service network design that take the form of complex network design problems.

Fransoo and Lee [58] argue that the planning of sea transport has received relatively little attention. Amongst other things, the authors point out that the quantitative modeling of the coordination of door-to-door transport of maritime containers, which involves a large number of organizations, is largely unexplored. The coordination between the shipping lines and the port operators in order to mitigate uncertainties of container throughput times would be an interesting example of coordination problems at hand.

Another planning problem that shipping lines address is the asset management of containers, in particular, the repositioning of empty containers after their use for cargo shipments; see for example [37].

1.4.2 The Role of Information Technology in Creating a Competitive Advantage

By a number of authors, information is viewed as a resource to be used in decision-making that enhances logistical performance (effectiveness, efficiency, and flexibility); see [25, 31, 131]. Closs et al. [35] discuss two broad streams of literature that investigate the relation between IT investments and logistics performance. In the first stream, information is viewed as a logistics resource: Information is conceptualized as a substitute for inventory. The more accurate the information, the higher the data transmission speed, and the lower the cost of computing, the better and the faster adjustments can be made in physical inventory levels. The second stream views information technology as a competitive weapon. This type of research is based on the underlying assumption that information technology contributes substantially to low transaction and communication costs. The empirical evidence in both streams of research on the relationship between IT investment and (logistics) performance is mixed and not abundant. We elaborate on this in Section 2.

In the information management literature, both performance effects of IT and its contribution to competitiveness have been subject to much debate over the last decade. The debate on the performance effects of IT is dubbed as the productivity paradox. It refers to the impossibility of researchers to demonstrate an unambiguous relationship between investments in IT and business performance. Although IS research at the organizational level has been able to show encouraging evidence on IT investments and business performance [19, 20] the debate on the productivity paradox still continues.

The contribution of IT to a firm's competitiveness has recently been discussed by Carr in his provocative HBR-article "IT Doesn't

Matter" [26]. Carr argues that as information technology has become a ubiquitous, inexpensive, and for everyone accessible technology the strategic value has diminished. The very power and presence of information technology in organization have turned it from a potentially strategic resource into a commodity factor of production. Other researchers concur with this argument. For example, Clemons [34] argued that IT has become a "strategic necessity", but not a source of competitive advantage. Carr makes an important distinction between proprietary and infrastructural technologies. The former can be owned by a single company which can employ the technology to firm-specific processes. The latter technologies offer far more value when shared than when used in isolation. Infrastructural technologies can (and even should) be replicated in order to add business value. Because of the infrastructural nature of IT it becomes hard for individual companies to achieve competitive advantage on the basis of IT.

The suggested non-competitive nature of IT has been criticized by several researchers. Bhatt and Grover [12] argue that Carr incorrectly does not distinguish between IT assets, like infrastructure, and the ability to manage these assets. In their study the authors found no significant effect of the quality of the IT infrastructure on competitive advantage but did find an effect of the IT expertise and relationship infrastructure (ability of the IT group to understand business needs and created (trusted) partnerships with business groups) competitive differentiation. These findings concur with the extensive research of Brynjolffson and Hitt [19, 20, 21] on the productivity paradox in which they conclude that investments IT per se do not result in improved performance but should always be accompanied with investments in expertise, training, and organizational change.

IT is applied to supply chains from two fundamentally different perspectives: exploitation and exploration; see [146]. Exploitation in this sense means the class of actions to improve operational efficiency, whereas exploration refers to the class of actions to pursue new possibilities. Although Inter-Organizational information Systems (IOS) in port operations could be utilized to explore new possibilities, most applications in the port are focused on exploitation by integrating systems from different parties in order to smooth physical good flows.

The focus in system design therefore tends toward automating existing processes, not much focus is put on providing intelligent support to human decision makers. Automating information exchange in supply chains helps to make inter-organizational processes more robust, especially when the information exchange is bi-directional through the creation of feedback loops [29].

Recently, several researchers have taken up the resource-based view (RBV) from the strategic management literature to refine the implications of this broader perspective on the relationship between IT and competitive advantage. The RBV emphasizes the relation between the performance of organizations and resources and capabilities that are firm-specific, rare, and difficult to imitate or substitute [11, 51, 148]. When applied to the domain of IT, IT capabilities can be defined to the organization's ability to assemble, integrate, and deploy valued IT-resources [11]. In the literature different IT-based resources and IT capabilities are distinguished on the firm level [11, 12, 67]. As we do not deal with individual firms but with ports we will apply the concept of IT capabilities to the port level.

1.5 Port IT Capabilities: Addressing the Challenges

Port IT capabilities can be defined as the abilities to leverage high-quality information for network integration through advanced information technology in ports. In this monograph, we discuss three main port IT capabilities that ports can develop: (1) the ability to integrate information processes by recognizing the need for and initiate information hubs that enables information sharing between organizations and planning and execution in a collaborative way; (2) the ability to provide technological inter-organizational infrastructures that support the integration of information processes; and (3) the ability to coordinate interests in the network to successfully implement the technological infrastructures, i.e., in such a way that the relevant stakeholders adopt and support the technological infrastructures. The main argument in this monograph is that the success of port community systems in ports depends to a large extent on the *IT capabilities* of ports to design, develop, and implement these inter-organizational systems. In this section we discuss the three types of capabilities ports that should develop.

1.5.1 The Ability to Integrate Information Processes

Central in our study are port Inter-Organizational information Systems (IOS) that aim to deal with environmental uncertainty, and support logistics integration and coordination in the maritime transportation network of physical, information, and financial flows, in which the port is a hub.

There are different levels in which information about containerized transport is being considered. First of all, the parties involved in intermodal transport are concerned with the maritime containers that need to be transported and transshipped. For example, the shipping line, being the owner of the maritime container, manages its assets and needs to source empty containers to fulfill transport orders. Logistics service providers receive orders for full and less than container loads. Containers need to be "stuffed" or "stripped", i.e., loaded or unloaded at distribution centers, where transport orders can be combined. Value-added services, such as condition monitoring or repackaging, are usually concerned with the cargo itself and require information on cargo level. The government has an interest at both levels. The integrity of the container is an important port security issue, while Customs and food safety authorities focus on the cargo itself. Obviously, the two levels are related. Managing the supply chain also requires information at both levels. The delivery of goods in a proper state requires cargo level information, while efficient handling of containers is simplified by focusing at the container level.

Containerization and intermodality in global logistic chains have pushed high-quality information and advanced information and communication technology to become key assets in the global competition of ports. Innovations in information technologies have radically reduced the time and costs of processing and communicating information [42, 88, 98]. According to Van Klink [162], the management of logistics has become the management of information flows. Information binds all processes and procedures among the players in the ports [6].

The advent of advanced information and communication technologies did not only change the speed and process capacity of information flows in ports but also induced the rise of decentralized, distributed decision-making structures in logistics chains. Information and communication technologies have radicalized the decoupling of the flow of information from the flow of physical goods [153]. A major implication of the rise of decentralized decision-making structures in logistic chains is that emphasis is put on becoming well-connected and well-orchestrated [66].

Ports can be viewed as geographically bounded hubs in networks that seek to manage and coordinate flows of goods, ownership, payments, and information within global supply chains [6]. As information hubs in these global networks, ports play an important role in identifying, analyzing, and coordination information between network members. The detrimental impact on supply chain performance of information distortion is apparent from the "Bullwhip Effect" [131]. Lee et al. [86, 87] have demonstrated that the bullwhip effect is caused by rational independent decision-making, i.e., not necessarily by systematic irrational behavior. To counteract the order variance amplification, it is required to improve information sharing and network coordination. Full information sharing, accompanied with coordinated decision-making can result in significant performance improvements [144]. Full information sharing is not a sufficient condition for supply chain integration. Performance can be sub-optimal when each decision-maker optimizes his individual objective function. Therefore, both information sharing and coordination are deemed to be essential for supply chain integration. A supply chain is fully coordinated when all decision are aligned to accomplish the global network objectives [131].

In Section 2, we elaborate on information and coordination in container transport. We shall argue that in order to manage container transport, we need monitor and control loops. We discuss performance indicators that can be used to compare target and actual performance, and we consider response measures to be deployed in the case when deviations exceed tolerance limits. Monitor and control loops require visibility in the supply chain and we elaborate on the benefits of visibility. We also discuss how port community systems contribute to the required information process integration.

1.5.2 The Ability to Provide Technological Inter-Organizational Infrastructures

As stated above, ports have been challenged by the information technology revolution and are expected to transform themselves into information hubs — in the extended global logistic chain — or network. Information hubs can be supported by IT infrastructures that act as intermediaries underpinning inter-firm relationships [31]. Electronic hubs, like port community systems, are inter-organizational information systems that have the capability to bind competing and cooperating firms together. By the use of advanced inter-organizational information systems, supply chains can share real-time POS, order, and inventory data and can transform into electronic hubs [31]. Electronic hubs thus have the potential advantage of achieving collective benefits that go beyond the firm or dyadic level (digital network advantage). However, information sharing and coordination are hindered by the unwillingness of network partners, e.g., to share information. Moreover, companies have to adopt or adjust document and technology standards, such as Electronic Data Interchange (EDI) to exchange information.

Global ports take special position in global supply chain integration in that they serve as electronic hubs to facilitate and coordinate information sharing. New generations of Port Community Systems (PCS) even go beyond the function of information sharing as they can serve a variety of supply chain processes with different application modules. Ports differ from firms in that they do not represent a legal or economic entity [40], but a collection of private and public organizations that have individual interests in sharing and not sharing information with their network partners. The information assets of ports are heterogeneously distributed across individual organizations. So far, little information is available about the performance of these PCS.

In Section 3, we discuss the architecture of inter-organizational systems based on some basic features; data capture, data storage and transfer, and data processing. We discuss to what extent existing PCS architectures have these features.

1.5.3 The Ability to Coordinate Interests in the Network

Physical infrastructure and facilities are not the only assets that provide ports with a competitive edge. Smooth and efficient systems for cargo handling and a well-functioning customs and port management system are important criteria for industry to locate facilities and for shipping lines to designate ports of call. These systems require communication and processing of information; and the use of the information in planning and execution of logistics and administrative activities. The handling of material, information, and financial flows has become more complex and requires innovative solutions. As a consequence, competition between ports depends progressively on the capability to foster information sharing between participants in port networks. The participants in these port networks have different interests and might be unwilling to share information with others whom they do not trust. In Section 4 the complexity of coordinating the set-up of an inter-organizational information system in ports will be discussed.

1.6 Port Community Systems: An Adequate Response?

The need for IOS in the port has since long been recognized. In many ports, the development of successful IOS in ports has not been easy. Our case description of developments toward the present PCS in Rotterdam elaborates on this (Appendix B.1).

The first IOS in the context of container transport were of a bilateral nature, where Electronic Data Interchange (EDI) messages replaced hard copy documents. The bilateral network architecture worked well for establishing connections between large parties that support many information exchange transactions. In container transport, EDI emerged at the seaside, between the large shipping lines (agents) and sea terminal operators. Due to different formats and the extension to the much more fragmented hinterland, there was a need for a central messaging infrastructure, where EDI messages could be routed to different parties and which supported the translation from one format

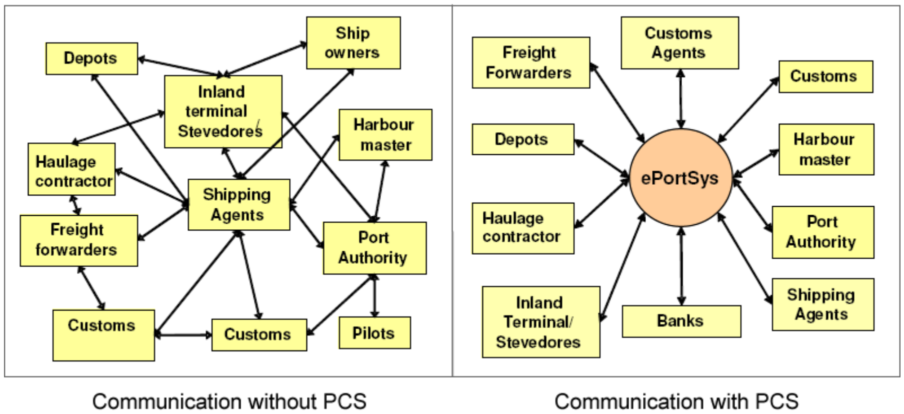

Fig. 1.2 Position of a port community system [127].

into another. This has led to the emergence of the first PCS in the 1980s.

A PCS can be defined as an electronic platform that connects the multiple systems operated by a variety of organizations that make up the port community [127]. A PCS system avoids bilateral data transfer as shown in Figure 1.2.

Port Community Systems (PCS) basically are used to standardize message exchange among stakeholders and centralize all community information as much as possible. By capturing the information produced in any exchange within the community, the need to retype data can be avoided. Electronic message exchange substitutes the exchange of physical documents (postal mail and faxes), thereby reducing errors and processing costs. In the end, PCS provide transparency and possibly real-time information, to facilitate the tracking and tracing of goods and reveal inefficiencies.

The question is to what extent the development of port community systems helps ports to develop their IT capabilities that are required to meet the challenges explained above.

1.7 Objectives and Set-Up of This Monograph

This monograph aims at providing insights into the ways global ports are challenged by the need for managing complex information flows in global networks. We identify three main challenges at different levels: information level, architectural level, and inter-organizational level. We argue that special port IT capabilities are needed to meet these different challenges. In the subsequent three chapters, we will discus the three port IT capabilities, as indicated in Section 1.5, in more detail. Moreover, we show how these capabilities have been developed to some extent in today's ports. In the sections, we either state examples from practice or refer to the full case descriptions of port inter-organizational systems in Appendix B. We conclude this monograph with describing current and future developments with which we expect to impact the future development of port IT capabilities.

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