Partie III

Human & Technology

Chapitre 13

Digitalization in maritime logistic sector

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Biography

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Abstract

Digitalization is revolutionizing the maritime logistics sector that has previously been relatively conservative. Nowadays there is an increasing amount of digital and electrical solutions that are used or could be used also in ports. New digital solutions are being developed every day. Within the transport and logistics sector, some companies are already experimenting with new connectivity and data-enabled technologies, leading to the Internet of Things (IoT) and industry 4.0. In addition, digital solutions that have been used and are found to be useful in other industry sectors can be adjusted to suit the needs of ports also.

Due to the high requirements in the logistics sector for productivity, efficiency, safety and sustainability, digital innovations are essential. The degree of digitalization varies between ports as large ports show a higher degree of digitalization than smaller ports. Bigger Central European ports, such as Port of Hamburg, have already incorporated digitalization deep into their operations, but ports, such as the ports in the Baltic Sea region, are still searching for solutions, that enhance their efficiency and productivity, are cost-effective, can reduce emissions, and suit the needs of smaller, often specialized ports. Thus, for example, advanced automated solutions, such as automated terminals, handling technologies and effective single-window systems are still lacking in several ports.

It is important that the ports decide which technologies to introduce and how to implement those technologies. The challenge with deciding on the right technologies lies in the variety of companies and ecosystems within ports. Different stakeholders operate different kinds of equipment and require different types of solutions. In addition, the data of the different operators is not necessarily compatible and the data transparency provides challenges as the port related operators include competing companies.

This paper consist of a current state analysis and predictions for the future of port digitalization in the Baltic Sea Region.

Keywords: digitalization, logistics, maritime, ports

Introduction

Background

Digitalization is revolutionizing technological trends, industry, and the maritime logistics sector that has previously been relatively conservative especially in the Baltic countries (e.g. Heilig et al., 2017; Leviäkangas, 2016; Kayikci 2018 & Fruth, 2017). Digitalization is a necessary tool for the needs of the logistics and transport sector. In logistics, different technologies, solutions and applications can be adopted, including mobile technologies, cloud services, sensors, data analytics, machine learning, big data, block chain and Internet of Things (IoT) (Leviäkangas, 2016; Kayikci 2018; Barreto 2017). Digitalization brings many advantages but also disadvantages to the whole shipping and logistics industry.

Digitalization brings many advantages, such as real time information and databases related to cargo. Even the International Maritime Organization (IMO) supports the implementation of automated electronic data exchange from ship to ship and ship to shore to increase efficiency, safety and security of maritime navigation and communications (Berg 2015). Digitalization and transforming industry around digitalization can also decrease environmental impacts (Berg 2015; Kayikei 2018; Gebler et al. 2014).

Due to the high requirements in the logistics sector for productivity, efficiency, safety and sustainability, digital innovations are essential (Heilig et al. 2017). Heilig et al. (2017) recognize three generations of digital transformation, which are paperless procedures, automated procedures, and smart procedures. Heilig et al. (2017) estimate that paperless procedures' transformation occurred in the 80s, automated procedures were introduced during the 1990's and 2010's and now is the time for smart procedure development. Nevertheless, Heilig et al. (2017) admit that the degree of digitalization varies between ports as large ports show a higher degree of digitalization than smaller ports. Some smaller ports have barely evolved into the paperless procedures phase and are merely at the beginning of the automated procedures era described by Heilig et al. (2017). Automated solutions, such as automated terminals, handling technologies and effective single-window systems are still lacking in several ports.

Digitalization can also bring disadvantages especially during the initial phase of digitalization. As different ports and shipping companies digitalize their operations at a different pace, companies can experience problems related to incompatible systems. If the digital solutions are separate and cannot communicate with each other, they can become an inconvenience instead of being a strength. In addition, the variation of digital solutions and rate of digitalization in ports affects the ports' competitive advantage. Smaller ports with fewer resources for digital

development are left behind in the competition. For example in Europe, bigger Central European ports, such as Port of Hamburg, have already incorporated digitalization deep into their operations, but ports in the Baltic Sea region are still searching for solutions, that enhance their efficiency and productivity, are cost-effective, can reduce emissions, and suit the needs of smaller, often specialized ports.

Disadvantages can also come from general attitudes towards digitalization, robotization and automation (Ministry of Transport and Communications, 2013). Labor Unions have relatively strong opinions and they are generally against digitalization, since they are afraid that digitalization decreases the need for employees in the port and within the logistic industry. For example, in Finland there was a case, in which a Finnish stevedoring company brought up a safety issue in port areas. It was noted that there should be some sort of an identification system for personnel who work in the area. Currently, there are smart clothes and tags for these kinds of purposes in the market, but Eurepean Union's general Data Protection Regulation denies personnel following with GPS systems or other similar systems, even though they would be very beneficial, if viewed only from a safety perspective. Thus, the stevedoring company in in the need of a passive recognition system, which would be more suitable in terms of workers, legislation and labor unions.

Within the transport and logistics sector in the Baltic Sea Region, companies are already experimenting with new connectivity and data-enabled technologies, leading to the Internet of Things (IoT). In reality, Baltic Sea ports are lagging behind and trying to catch up. Currently there have been some attempts at development related to e.g. automation technologies, but there attempts remain isolated (Vonck, 2017).

Research and methodology

The aim of this paper is to establish the current state of digitalization and development trends in ports and, based on that, build an estimation on the development prospects of port digitalization in the Baltic Sea region. During the current state analysis, a literature review will be performed, during which the digital solutions that are currently being used and developed in the maritime sector will be discussed. Based on the literature review, predictions are made on the future of port digitalization. The structure of this paper is as follows: chapter 1 will establish the background of this study. Chapter 2 will discuss the current state of port digitalization. Chapter 3 presents the future predictions. Chapter 4 consists of the discussion and conclusion of this study.

Current state of digitalization in ports

Nowadays there is an increasing amount of digital and electrical solutions that are used or could be used also in ports. The whole transport network is changing, and transportation volumes are becoming larger. In addition, there are increasingly more and more players and operators in the transport network, who want to use and process information using breakthrough technologies and concepts (block chain, physical Internet, etc.). New digital solutions for different purposes are being developed every day. In addition, digital solutions that have been used and are found to be useful in other industry sectors, such as aviation and road transportation can be adjusted to suit the needs of ports also. The next step is that the ports need to decide which technologies to introduce and how to implement those technologies. The challenge with deciding on the right technologies lies in the variety of companies and ecosystems within ports (Vonck, 2017; Leviäkangas, 2016; Barreto et al. 2017; Witkoswski, 2017).

Different stakeholders operate different kinds of equipment and require different types of solutions in the different ecosystems. In addition, the data of the different operators is not necessarily compatible and the data transparency provides challenges as the port related operators include competing companies (Vonck, 2017). Digitalization of ports offers many opportunities for ports to improve their efficiency and productivity, security and sustainability (Pernia & de los Santos, 2016; Heilig et al. 2017). The amount of potential digital and electrical solutions is vast and in constant change. Thus, it is not feasible to discuss all of them separately. For the purpose of this study, the different digital solutions have been separated into three main groups based on their use and purpose. These groups include:

- Digital and electrical solutions that improve port efficiency and productivity.
- Digital and electrical solutions that reduce emissions or improve sustainability.
- Digital end electrical solutions that improve port safety and security.

Digitalization in ports causes operational changes also, which requires commitment from different stakeholders in the whole logistics change. According to previous studies, smaller companies do not have similar recourses as bigger companies. It is also clear that, in smaller ports, cargo volumes are relatively small, thus making investments on digitalization and new technology unreasonable. This leads to a situation, in which the logistic chain is only partly digitalized and smaller companies and ports are automatically out of this digitalization process (Kunnaala-Hyrkki et al., 2015).

Generally, everyone within the port sector is interested in digitalization. Some ports have digitalization strategies or plan to do something towards digitalization.

Nevertheless, it seems that some actors do not fully understand or know what their organizations role is, when it comes to digitalization and how they can benefit from it. Digitalization does not mean that information is in an electrical mode or in the internet as a pdf or word document. Ports must understand what they can do, when they can get information from, for example, intelligent sensors, different platforms such as 4G, 5G and 6G, connected mobile devices, stakeholders commercial electronic devices and applications, and connection to infrastructures. Digitalization and IoE in the port sector means that the ports' receive massive volumes of data from different sources and provided by different actors and stakeholders. The ports need to assess whether and how they can benefit from this information flood and can they, for example, open the data to developers who create and improve logistics operations or use the available information as in decision making. Nowadays ports are rather closed systems and attitudes are often against the idea of open data sharing. Ports and the logistic sector require more information about digitalization and the solutions it provides (Leviäkangas, 2016; Srai & Lorenz, 2018; Kane et. al., 2015; Conca et al., 2018; Bechtsis et al., 2018).

As stated above, digital solutions in ports can be divided roughly into three categories: solutions that improve port efficiency and productivity, solutions that reduce emissions or improve sustainability, and solutions that improve port safety and security. Next, different solutions within the categories that are used in present day ports will be established.

Digital and electrical solutions that improve port efficiency and productivity

When digital solutions are developed, the focus is often to increase efficiency and productivity and to decrease costs. Efficiency and productivity can usually be measured in saved time and resources or other benefits. Larger ports with ample resources have also invested in automation and robotization in cranes operations, or in automatized terminals, which reduce personnel costs and result in saved time. Yet, cargo volumes must be relatively large in order for such investment to be profitable (Leviäkangas, 2016; Witkowski, 2017; Kunnaala-Hyrkki et al. 2015). Before investment and digitalization, the required resources must be planned. Digitalization brings visibility and transparency to the logistic chain and to port activities, which means more resources to people, materials and equipment. Implementation of digitalization and IoT need specialization of human resources and new skills from the workers and human resource industry (Barreto et al., 2017; Witkowski, 2017; Qin et al., 2016).

In the perspective of efficiency and productivity, ports are complex operational environments comprised of different stakeholders who need to work together to maximize port efficiency and productivity. Thus, collaborative sharing of data is a prerequisite (Pernia & de los Santos, 2016). In the future, ships can provide ports with more accurate information regarding the cargo, which allows better planning and faster unloading from port operators. Radio-frequency identification (RFID) in containers, or integrated in goods, allow tracking and monitoring goods for better-optimized transport and distribution (Berg 2015; Kayikei 2018). In addition, digitalization can solve problems related to trucks' waiting times and possible bottlenecks in ports. Sensors, barcodes and tracking devices are in use to get real time information on track and trace, and in loading and unloading processes. Just in time (JIT) is a bottleneck in logistics chains and it can be tackled with real time information. In the port areas, one of the largest problems is the waiting time i.e. the time trucks or rail wagons wait for loading or unloading in the port area (Giuliano & O'Brien, 2007). This causes delays and congestions. With real time information and right planning, unloading or loading process can done more smoothly as the trucks or railway wagons do not have to wait in the port area and they can arrive just when they are needed. Warehouses are vital part of logistic chain.

IoT brings new technologies for ships and working machinery in ports. Machinery and equipment in ships and working machines can be fitted with sensors and transmitters that report performance and early signs of malfunction. Consistently repairing or replacing faulty systems during the ship's stay at the home port can save time and money, since the cost of flying technicians and parts to a ship's location in transit is substantial. In addition, real-time updates on weather systems, wind and ocean currents enables captains to readjust navigation for lower energy consumption.

Today smart warehouses produces competitive advantage to customers and logistic provider. Warehouse integration needs commitment from actors and stakeholders, which leads to integration with transport system. Transportation and warehouses must be connected and communicate in order to achieve optimizations in JIT and to increase efficiency and productivity (Barretto et al. 2017; Witkowski, 2017; Conca et al. 2018).

Port Community Systems (PCS), which are connected ICT and ITS systems, increase the efficiency of port and decrease environmental impacts (Carlan et al. 2016; Brunila et al. 2011). In the Baltic Sea region, there are only few PCS systems in the ports. The largest ports have their own systems. In Finland, there are no bilateral PCS, because transport volumes in the ports are not big enough to cut the costs. On the other hand, some companies have built their own networks amongst the port, port operators and transport companies. Other companies have their own systems. In the end, many different systems could be combined as a one PCS. Competition between companies and earlier investments lead to

a situation, in which in the near future, smaller ports do not have the possibility to have or connect to PCS (Brunila et al. 2011; Carlan et al. 2016; Cepolina & Ghiara, 2013).

Digital and electrical solutions that reduce emissions or improve sustainability

One key element in the competition of ports now and in the future will be their environmental statuses and their capability to respond to the challenges of sustainable development (Brunila & Anttila 2013).

Ports' environmental best practices can include digital and electrical solutions, such as dimming lights (Kunnaala-Hyrkki et al. 2015). One efficient way to reduce the environmental effects of ships during port visits is electric power supply from shore to ship as the electrical connection eliminates the need to run the auxiliary engines (Brunila et al. 2015).

It should be noted that, even though a division between the three different categories of digital solutions can be done, the solutions often produce all three kinds of benefits, efficiency, sustainability and safety. The other benefits gained can often be indirect or unintended, but they are nevertheless desirable. According to a questionnaire study performed by Kunnaala-Hyrkki et al. (2015), ports considered enhanced cost-effectiveness and increased efficiency with new technologies to be the third and fourth most important positive effects that port's voluntary environmental actions can have.

ICT, ITS and PCS can bring forth also environmental benefits. With the systems, emissions can be reduced through the intensification of logistics activities, and the decrease of paper documents and use of printing paper due to the use of electronic documents provided by a PCS. A PCS can also affect indirectly to the environmental aspects of logistics through, for example, optimisation of transport routes and load capacity, tracking of cargo and central servers. Despite the potential environmental benefits, economical profits and service content are usually considered the more important factors, when ICT systems are designed and deployed. However, green values should be taken very carefully into account in the planning and implementation of PCSs since they can bring a major competitive advantage to related actors and promote environmental protection in a broader perspective as well (Brunila et al. 2011).

Digital end electrical solutions that improve port safety and security

The most effective incentive for ports to introduce solutions related to sustainability, safety and security is legislation. For example, requirements for emission measurement and control can spark digital innovations as ports strive to comply with regulations. Both EU and national legislation regulate the port operations and set different kinds of economic incentives or disincentives to the operation. Regulatory instruments include for example jurisdiction and law based decrees, restrictions and licenses (Kuronen & Tapaninen 2010). Regulatory instruments are effective and easy to enforce, but their implementation and enactment can be expensive and difficult (Vieira et al. 2007). In addition, regulatory instruments do not always promote innovations but rather create resistance (Klemmensen et al. 2007; Vieira et al. 2007). Yet, digital innovations can give the port advantages, since innovations can take the ports' environmental performance farther than regulations require. Thus, the ports have vantage, when new, stricter environmental and safety regulations come to force (Kunnaala et al. 2013).

When it comes to the safety of the personnel working in the port areas, couple of safety risks can be solved or at least minimized with digital solutions. One security problem is related to disinfection of containers. Disinfection is a simple and effective way of removing pests from containers and preventing them from causing damage to the cargo. Unfortunately, the use of disinfectant gases at the same time insidiously endangers the safety and health of workers handling containers. Exposure to disinfectant gas is always a serious matter, as these gases are dangerous to any living being - whether it is a chemical or a chemical already banned in the European Union. Against that exposure, workers can train for safety issues but there are also novel equipment that can detect the gases before the personnel handles the containers.

Another risk factor in the port areas is related to personnel movement within the port area. There are always risks for the employees, if they have to travel within the port, especially on foot. This is due to the fact that there are several large working machines operating within the port area almost continuously. Thus, novel tracking equipment and smart clothes have been developed in order to improve the safety of workers.

It should be noted that digitalization also gives rise to new security threats. Especially threats related to cyber security need to be taken into consideration, when ports carry out their information exchange. In addition, information related to cargo movement and cargo types can sometimes be sensitive and thus, has to be handled with care. Open data, shared systems, interconnected networks and information interfaces make port operations more effective and productive, but also make the ports more vulnerable to cyber attacks. Cyberattacks are usually

targeted at port operators inside the port area, since they tend to have fewer security controls than the port itself (Shackleford 2015; Barreto et al. 2017).

For ports, cyber security threats include, for example, an action to delete operational data containing time schedules and information for container shipments. In addition, a cyberattack may gain access to commandeer a ship, close a port or its terminal, access delicate information and change manifests or container numbers. Even the smallest cyberattacks can lead to significant losses (Caponi & Belmont 2014; Jensen 2015). Potential vulnerabilities of ports include, limited training and readiness for cyber security, software errors and connection and interdependence of networks (Homeland Security 2016).

The future of port digitalization

Digital transformation in ports can be divided roughly into three generations: paperless procedures, automated procedures, and smart procedures (Heilig et al. 2017). Yet, it should be noted that the degree of digitalization varies between ports as large ports show a higher degree of digitalization than smaller ports. This is particularly evident in the smaller ports of the Baltic Sea Region. The ports have barely evolved into the paperless procedures phase and are merely at the beginning of the automated procedures era described by Heilig et al. (2017).

The basis for paperless procedures was in the development of ports. Due to ports evolving from simple loading and discharging points to intermodal logistics service hubs, there was a growing need to ensure efficient information flows. The main focus was in EDI Electronic Data Interchange (Heilig et al. 2017). According to Heilig et al. (2017), the second era of digital transformation in ports was related to automated procedures. The new innovations included, for example, automated container terminals, automated handling technologies and automated identification systems. In addition, information exchange became more effective and complex through, for example, single-window systems.

Many smaller ports in the Baltic Sea Region have succeeded in implementing effective information exchange and paperless procedures, but automated solutions, such as automated terminals, handling technologies and effective single-window systems are still lacking in several ports. Some partly automated systems and identification systems have been adopted but the full revolution of the terminal equipment and IT infrastructure has not yet fully occurred.

Digital solutions for efficiency

As shipping companies and supply chains become more digitized, ports must follow the trend. Digitalization has to reach the whole supply chain and all its actors so that the full benefits of digitalization actualize. In addition, there is a possibility that shipping companies begin deciding their ports based on the port's level of digitalization. Whether the port's digital systems are compatible with the shipping company's systems or not, can also become an issue.

Real time information on cargo movements and activities of the port operators can be considered one of the most beneficial digital solutions that improve port efficiency. In order to achieve maximum benefit from information, almost all port data should be open and available. In addition, all the systems of different port related operators should be available and compatible. Common sharing of data and information, and creation of common service platform is preferable. It should be noted that open data sharing solutions can also face resistance. Ports and logistics companies can sometimes have a problem with sharing data and information, because they do not want to share information with their competitors, who might benefit from the data.

It can be estimated that the next steps in Baltic Sea ports' development are related to automation, equipment integration and more efficient data flow. What is hindering this development is lack of resources. This is typical for smaller ports, since equipment development and updating requires a lot of resources at once. Another challenge for the next development stage is lack of information sharing and cooperation. Port related operators do not necessarily identify the advantages of open data and information exchange and sometimes information is withheld on purpose. In addition, the incompatibility of data sources and systems can become a problem.

The third generation of port's digital development, which is smart procedures, is still in the far future for many Baltic Sea ports. Some common smart applications and procedures, especially for information exchange purposes have been adopted, but groundbreaking innovations are still lacking. It is likely that especially the larger ports in the Baltic Sea Region that have not yet entered the smart procedures era will adopt the basic digital solutions related to efficiency, productivity and information exchange in the near future. This also applies to ports operating as important transportation nodes. Fluent exchange of data is especially important when it comes to multimodal transportation in ports, where there is a risk for delays and congestions. Nevertheless, these digitized ports in the Baltic Sea region have to maintain their ability to operate without digital tools and communication devices, because for several years still there will be operators and companies with aversion to digitalization that refuse to evolve beyond paperless procedures.

When it comes to smaller ports, the situation might vary from port to port. Sometimes ports, especially smaller ports, can be specialized or serve only few customers. Specialized ports are less likely to invest in digital solutions due to lack of resources and lack of incentives, unless their customers require such solutions. It can be estimated that smaller ports will not adopt digital solutions beyond requirements in the near future.

Digital solutions for sustainability, safety and security

The most effective incentive for ports to introduce solutions related to sustainability, safety and security is legislation. Unfortunately, regulatory instruments do not always promote innovations but rather create resistance (Klemmensen et al. 2007; Vieira et al. 2007). Yet, digital innovations can give the port advantages, since innovations can take the ports environmental performance farther than regulations require. Thus, the ports have vantage, when new, stricter environmental and safety regulations come to force (Kunnaala et al. 2013).

One key element in the competition between the Baltic Sea ports now and in the future will be their environmental status (Brunila & Anttila 2013). Not only actors in the supply chain, such as shipping companies, but also the society is expecting that the ports take responsibility of environmental protection and safety (Van Breemen et al. 2008). Therefore, adopting digital solutions related to sustainability and safety can become a significant competitive advantage even for smaller ports. It should be noted that digitalization also gives rise to new security threats. Especially threats related to cyber security need to be taken into consideration, when ports carry out their information exchange.

Thus, it can be assessed that ports in the Baltic Sea Region will adopt new digital solutions for sustainability, safety and security. Mostly because they have to in order to follow regulations, but also partly in order to improve their operations. In addition, all ports have to prepare for cyber security issues hand in hand with their digital development. It is likely that larger ports with more digital solutions, more safety and security risks and more attractiveness to cyber attackers will adopt more safety and security solutions that smaller ports.

Discussion and Conclusion

In this study, the aim was to perform a literature analysis on the current state of digitalization and development trends in ports and, based on the literature analysis, build an estimation on the development prospects of port digitalization in the Baltic Sea region.

Digitalization of ports offers many opportunities for ports to improve their efficiency and productivity, reduce emissions and improve sustainability, and improve safety and security. As the study showed, ports are a part of the digitalization trend, but they required more information about what are ports' role, when it comes to digitalization and how they can benefit from digitalization. Digitalization brings many advantage but also disadvantages to the port environment.

Digitalization can also solve several problems that ports face nowadays. One of the biggest bottlenecks in port operations is waiting time in the port area for loading and unloading on goods. In order to tackle the problem, several techniques have been adopted, such as, sensors, RFID, GPS, ICT, IoT, PCS, 4G, 5G, 6G, automation, robotics, block chain etc. Thus, it can be said that there are several technologies already ready for different purposes and for digitalization of ports.

Bigger ports within the Baltic Sea region that have more resources have already adopted some of these techniques for their daily operation but some ports are still looking for techniques that would suits their purposes. As shipping companies and supply chains become more digitized, ports must follow the trend. Digitalization has to reach the whole supply chain and all its actors so that the full benefits of digitalization actualize. Digital innovations can give the ports competitive advantages, but also other advantages, especially when it comes to environmental innovations. Since innovations can take the ports' environmental performance farther than regulations require, the ports have vantage, when new, stricter environmental and safety regulations come to force.

One key element in the competition between the Baltic Sea ports now and in the future will be their environmental status. Not only actors in the supply chain, such as shipping companies, but also the society is expecting that the ports take responsibility of environmental protection and safety. Therefore, adopting digital solutions related to sustainability and safety can become a significant competitive advantage even for smaller ports. It should be noted that digitalization also gives rise to new security threats. Especially threats related to cyber security need to be taken into consideration, when ports carry out their information exchange.

It will take a long time, until ports in the Baltic Sea region are fully automatized. For example in South-East Asia, some ports are already automatized, but these ports are often larger with more resources. Within the Baltic Sea region, ports are still relatively conservative and thus it will take time. Nevertheless, the first steps towards automation and smart processes have already been taken.

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