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Improving the seaport service quality by implementing digital technologies

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ABSTRACT

The process of digitalization i.e. implementation of digital technologies is widely present in the seaports. Digitalization encourages seaports to adjust and implement digital technologies in providing their services, while constantly striving to stay efficient, profitable and competitive. The implementation of digital technologies results in altered perspective of seaport service quality. Since seaport service quality is not prescribed and strictly defined, the importance of digitalization should be taken into consideration, which includes redefining the seaport service quality factors. Worlds' leading seaports, especially leading European seaports, recognized the possibilities of digital technologies in providing quality seaport services and are investing in their implementation. In this paper, seaport service quality is analysed in the context of digitalization i.e. the implementation of digital technologies. The purpose of this paper is to define the quality factors and opportunities for improving seaport service quality based on the analysis of digital technologies implemented in seaports.

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1 Introduction

Seaport services have evolved along with the development of seaports. Initially, seaports provided simple loading and unloading services, while today seaports act as a main links in the international maritime transport offering various services and connecting many stakeholders.

Seaports are constantly influenced by the changes in economy, transport, technology, etc., which affect seaports services i.e. seaport service quality [8]. The process of digitalization in seaport business influences and changes the provision of seaport services and seaport service quality, which has transformed when taking into consideration the changes in seaport operations and seaport services [2]. At first, seaport service quality was simple, referring merely to the successful or unsuccessful loading and unloading operations. It has gradually evolved into a complex quality consisting of various factors which could include: reliability, flexibility, innovativeness, technology, security, etc. [20]. Seaport service quality in the theoretical and practical sense is not uniquely defined, but should include all relevant factors of the seaport business and a broader perspective of issues which influence the seaport business, such as the process of digitalization.

Digitalization i.e. the implementation of digital technologies is one of the processes which today strongly influences seaports and the provision of seaport services. Leading seaports recognized the importance and potential of digital technologies in providing the service quality and remaining competitive.

This paper studies seaport service quality in respect to the process of digitalization in seaports, particularly the necessity to consider the changes in the definition of seaports service quality factors regarding the implementation of digital technologies in seaport services. The goal of this paper is to define seaport service quality factors from the aspect of implementation of digital technologies in seaport services and to provide a review of relevant examples of digital technologies implemented to improve seaport service quality.

2 Literature review

In this chapter authors provide brief review of the relevant literature i.e. previous researches regarding the seaport services, seaport service quality, digitalization in the seaports and digital technologies in the seaports.

Dawidowicz and Posta [3] defined the providing of seaports service as ordered sequence of organizational, logistical, technical, technological, economic and legal processes as well as actions and activities connected with the process of delivering goods from origin to destination. Furthermore, the authors defined four groups of seaport services. Basic services include transshipment, warehousing and transportation within the seaport. Additional services include operations related to cargo (customs control, container weighing, container washing, etc.). Specific services depend on the type of the cargo and thus include: temperature control, veterinary and phytosanitary control put on/put off a portable generator into a container, etc. Logistics services include insurance, distribution, freight forwarding, consulting, advertising, etc.

Stopka, Gašparik and Šimkova [18] analyzed the seaport transportation services. The authors defined the seaport transportation services as all activities related to cargo transfer, as well as the accompanying services: palletizing, labelling, computer support, coding, etc.

Dwarakish and Salim [4] defined three groups of seaport services: infrastructure services (provided by port authorities), cargo handling services (provided by private firms) and other services such as mooring, towage, etc.

Hoang Viet [9] provided a survey in the "Saigon Newport Corporation", which governs six Vietnamese seaports, to analyze seaport service quality and customer satisfaction. The author defined the following seaport service quality factors: resources, capacities, processes, management, image and responsibility. Respondents ranked the following factors as the most important for seaport service quality: resources, capacities, processes of services, management capacities, image and reputation.

Yeo, Thai and Roh [22] researched seaport service quality and customer satisfaction in the Korean seaports and determined the following factors of seaport service quality: resources, outcomes, process management, image and social responsibility.

Pham and Yeo [15] conducted a research of service quality in five container transshipment terminals in Vietnam, from the perspective of shipping companies. The authors analyzed which factors (responsiveness, efficiency, reliability, empathy, route and location, and cost and charge) have the greatest influence on seaport service quality. The shipping companies responded that responsiveness, empathy, route and location, and cost and charge have the greatest influence on seaport service quality.

Hirata [7] conducted a research on seaport service quality and customer satisfaction in container liner shipping and analyzed the following characteristics of seaport service: point-to-point schedule, on-time load and delivery, availability of container, freight and digital solutions, knowledge of sales representative, customer service representatives, timeliness of communication and response to service failures. The research showed that digitalization along with customer service representative and quality of sales representative has the greatest impact on seaport service quality.

Thai [19] analyzed the impact of seaport service quality on customer satisfaction in the Port of Singapore, including the concept of Port Service Quality (PSQ) and its influence on customer satisfaction. The participants in the survey were shipping operators, cargo owners and their representatives (freight forwarders and logistics service providers) who are users of the services in the Port of Singapore. Respondents assessed on-time delivery of a shipment, selection and deployments of resources in the most efficient way as the most important factors in ensuring customer needs and expectations.

Kaliszewski [11] analyzed seaport service according to the generations of seaport development. The author determined six generations of seaport development. Seaport service quality in the 5th generation seaport, which present in seaports, is characterized by exceeding the standard of services expected by the port stakeholders. The author considers seaport service quality in the future 6th generation seaport, which should comprise the technical and organizational innovations, complying with the social and environmental aspect of the seaport business.

Hlali and Hammami [8] researched the concept of the service in five generations of seaports. According to the research, seaports are currently in the 5th generation, which focuses on the customers' requirements. Thus, communication strategies that clearly articulate the seaport service offering and value, marketing framework aimed at enhancing customer loyalty and measuring customer satisfaction, are crucial in the competitive seaport environment.

Sanchez-Gonzalez et al. [16] made a systematic literature review regarding digitalization in maritime transport. The authors analyzed the digital technologies in ship design, shipbuilding and seaports. They concluded that the seaport sector offers great opportunities for further studies on digitalization, especially regarding the interaction with inland transport.

Inkinen, Halminen and Saarikoski [10] made a study on how stakeholders in Finnish seaports see digitalization. The respondents (47.4 %) answered that they have a significant need for digitalization and 36 % of respondents answered that they have the highest need for digitalization. The authors also stated that digitalization is developed in seaports through their strategic plans and concrete projects.

Nistor, Popa and Gavra [14] considered seaport service quality as an important factor in seaport competitiveness. Furthermore, the authors concluded that seaport competitiveness is closely related to the role of digitalization in the improvement of the seaport services quality.

Heilig, Shwarze and Voss [5] determined the digital innovation as essential for seaport competitiveness.

Sifei, D., et al. [17], consultants at consulting houses Accenture and SIPG, made a study "Connected Ports-driving future trade", in which digital technologies are considered as important for upgrading and transformation of seaport services.

3 Digitalization of seaport services

Digitalization i.e. the implementation of digital technologies pervades the seaport business. In the incoming years, it is expected that digitalization will change business models, processes and activities in the maritime industry i.e. seaports and digital services will be increasingly implemented [6]. Furthermore, it is expected that seaport service quality in the future will be determined by the digitalization and sustainability of seaport operations [17]. This paper focuses on digitalization, whereas sustainability will not be analyzed.

There are several reasons why seaports implement digital technologies in providing their services [25]:

- Increased vessel size and cargo volumes in the international trade forces the seaports to implement digital technologies to provide quality services and to be productive, efficient and competitive.
- Digital technologies enable seaports to adapt their services according to desired role in regional and global trade and according to their specific commercial and operating needs.
- Digital technologies enable seaports to maximize the return on investments. Through implementation of digital technologies, seaports improve their services, become more competitive which in the end brings more profit.

Furthermore, digital technologies are being implemented in various segments of seaport operations which are a part of service process and which include various stakeholders [25]:

- Infrastructure and superstructure: monitoring of proper function and status of the seaport infrastructure and superstructure. Digital technologies enable seaports to track, operate, monitor and maintain physical infrastructure and superstructure efficiently.
- Cargo handling: enhance productivity by optimizing cargo operations. Digital technologies enable seaports to monitor the seaport cargo handling equipment reliably and operate on peak efficiency, which ultimately improves productivity.
- Intermodal traffic: coordination of vehicle movements to improve traffic flow between seaports and cargo destinations. Digital technologies enable seaports to direct trucks and trains more efficiently through congested areas.
- Customs and collections: streamline the sharing of the cargo and customs information and documents. Digital technologies enable seaports to improve cargo information and document flow, as well as simplify the process of payment, processing trade licences, import and export permits and custom clearances.
- Safety and security: control of the seaport access, detection and early warning systems. Digital technologies enable seaports to monitor all physical elements and control the movements of personnel and users in the seaport area (proper authorization).
- Energy and environment: reducing energy consumption and monitoring the environmental impact. Digital technologies enable seaports to reduce energy consumption and waste.

Seaports can choose various digital technologies to implement into their services, but the choice depends upon the competition which seaports are facing, current business results, size of the seaport, location of the seaport, role in the trade, strategic goals of the seaport, etc. [25]. Digital technologies are not used equally in all seaports. Seaports, mostly small and mid-sized, still lack digital technologies in providing services and are thus less competitive compared to the seaports which implemented digital technologies. Digital technologies are currently mostly used in the world's leading seaports in which service quality is a priority to stay competitive among similar seaports. Currently, digital technologies which are most frequently implemented in leading seaports for providing seaports services are the following:

- IoT (Internet of Things) [33]: a system of interrelated computing devices, mechanical and digital machines, objects and people with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
- Big Data analytics [38]: a form of advanced analytics, which involves complex applications with predictive models, statistical algorithms and what-if analysis, powered by a high-performance analytics system to improve business decisions.
- Cloud computing [42]: providing services via the Internet without need for hosting information on a computer's hard drive.
- Machine learning [43]: a category of algorithm that allows software applications to become more accurate in predicting outcomes without being explicitly programmed. The basic premise of machine learning is to build algorithms that can receive input data and use statistical analysis for predictions.
- Digital twins [36]: virtual replicas of physical devices to run simulations of operations, processes, etc.
- Blockchain technology [29]: a reliable, difficult-to-hack record of transactions. Blockchain is based on distributed ledger technology, which securely records information across a peer-to-peer network.

- 3D printing [44]: a process of making three dimensional solid objects from a digital file.
- Artificial intelligence (AI) [24]: simulation of human intelligence in machines that are programmed to think like humans and mimic their actions.
- Sensor technology [40]: devices that collect the information from the environment (e.g. movement, noise, temperature, water level…) via IoT to provide insight into the process and enable analysis.
- Augmented reality (AR) [32]: a view of the real physical world in which users find elements enhanced by computer-generated input. AR technology enables to see elements that do not exist in reality through applications on the screen of a device – a mobile phone, tablet. These elements extend the reality, but only if viewed through the screen.

Since seaports provide their services in collaboration with many stakeholders, the stakeholders should also implement those digital technologies. As already mentioned, seaports can choose which and how many digital technologies they will implement in providing their services. Digital technologies also influence seaport employees, which are an important part of the service process as they are directly involved in providing the services. Digitalization implies changes in the nature of seaport employees and the way they work. The emphasis is on their skills to use the digital technologies [46]. It is expected that digitalization will change a large number of existing jobs in the seaport sector, which will be replaced with new job profiles over time [45].

Seaports that want to provide quality services and stay competitive, productive, customer friendly and efficient should implement digital technologies and adopt a digital mindset [25].

4 Seaport service quality factors

The conducted researches on the seaport service quality indicate that there is no unique definition of seaport service quality as different authors define different seaport service quality factors. Seaport service quality has changed along with the development of seaports and changes in the range and type of seaport services. At the beginning, seaports provided simple loading and unloading services. Further development of seaports brought an extended range of services, including industrial and commercial services. In the next evolution phase, seaports became links in the international production and distribution system. Then seaports became networked and provided door-to-door services. From the networking phase, seaports upgraded their services to the level focusing on customers' requirements, stakeholders' requirements and technology as vital factors in providing quality seaport services [8]. Each of the phases influenced of the definition of seaports service quality. Furthermore, seaport service quality can be observed from different aspects: seaport operations, users of seaport services and seaport stakeholders, but also from broader aspects such as environment and society, etc.

Trends in transport and logistics, e.g. digitalization and sustainability, require seaport business to adapt and thus imply changes in the definition of port service quality factors. Currently, seaport services are adapting through the implementation of digital technologies.

According to the relevant researches presented in the literature review and analyzed digitalization of seaport services, the authors define the seaport service quality factors as follows:

- Reliability: the service provided in a contracted time without obstacles and repetition. Reliable seaport service should be accurate and provided completely according to all contracted terms [12]. Reliability as a port service quality factor depends greatly on all seaport stakeholders involved in providing seaport services (e.g. forwarders i.e. logistic operators, etc.) since they contribute to the total time of the seaport service and fulfilment of contract terms.
- Flexibility: seaports should adapt their services or a part of the service to users' requirements [13]. Seaports should be flexible to adapt their services continuously, but also in the case of special requirements of users (e.g. in the case of unpredicted situations for users). An important part of flexibility is simplification of procedures for users (e.g. payment procedures).
- Security: the decrease of risks regarding cargo loading and unloading operations; control procedures at the entrance or exit of the port; track and trace of the cargo in and outside of the seaport area; surveillance of the seaport area [13]. Security enables unobstructed process of providing seaport services in terms of elimination of potential internal (unpredicted situations like fire, employees injuries etc.) or external threats (unauthorized entrance in the seaport, picking up/leaving wrong containers, etc.).
- Digital-based infrastructure and superstructure: loading and unloading operations as the core part of the seaport service process should be fast and unobstructed; otherwise, it will cause bottlenecks in the whole service process. Thus, seaport infrastructure and superstructure should be equipped with digital technologies (e.g. sensors on the cranes that monitor status and operating conditions and collect real time data via IoT [25]. Collected data enable quick reactions and better planning of operations) to provide quality seaport services.
- Digital skills: implementation of digital technologies changes the way that seaport employees (administrative and non-administrative) work to provide seaport services. Since seaport employees are directly involved in the process of providing seaport services, they have to be able to use various digital technologies and should adopt a digital mindset (attitude and behav-

iour that enables to foresee the possibilities of digital technologies in the work) [1]. Seaport employees with digital skills are able to provide quality seaport service. Furthermore, besides seaports employees all seaport stakeholders involved in providing seaport services should also have digital skills.

The authors believe that sustainable seaport operations should be considered as seaport service quality factor, because sustainability is one of the most important topics for future of seaports business [20]. Sustainable seaport operations could be defined as the optimal use of seaport resources, minimization of pollutants, minimization of gas emissions and compliance with seaports' surrounding society needs and expectations [27]. Since sustainability in the seaports is not analyzed in this paper, this potential seaport service quality factor will not be further dealt with.

Each seaport service quality factor has its significance and contribution in providing seaport service, but their synergy contributes to the maximum seaport service quality. Service quality increases the reputation of a seaport and strengthens the seaport's competitiveness. Quality, efficiency and cost-effectiveness of seaport services are considered as decisive in attracting users and maintaining seaport competitiveness [25].

5 Potential of digital technologies for the improvement of seaport service quality

Considering the determined seaport service quality factors: reliability, flexibility, security, digital-based infrastructure and superstructure and digital skills, this chapter brings a review of digital technologies implemented in seaports to provide seaport service quality.

The implementation of digital technologies in seaports enables reliable seaport services. Information exchange and simplified communication with customers and stakeholders involved in providing seaport services represents a basis for reliable seaport services. Furthermore, it is estimated that the cost of inefficient real-time information counts to 36 billion $ yearly and digital technologies could save 8.5 billion $ yearly [50]. For example, the Port of Rotterdam uses Cloud and Big Data technologies integrated into a CargoSmart platform [34], to provide information about ships (schedule and route options). Through estimation of ship arrival and departure, a seaport can organize all operations on time and react promptly in case of unpredicted situations which disable reliable services for customers. The Port of Los Angeles and the Port of Long Beach implemented the information portal "Port Optimizer" [48], based on Cloud technology. Prior to the implementation of the Port Optimizer, it was necessary to visit 12 different websites in the process of leaving or picking up a container. The Port Optimizer integrates all stakeholders and enables monitoring and adequate response to risky situations. The Port Optimizer enables reliable and improved service, besides increasing seaport efficiency by 8-12 % [48]. Reliable seaport services depend greatly on all stakeholders involved, especially forwarders i.e. logistic operators. Logistic operators act on behalf of many stakeholders: importers, exporters or other companies, to organize safe, efficient and cost-effective transportation of goods. For example, Damco implemented "Twill" [1] – customer collaboration platform based on Cloud technology and Big Data Analytics. Before the implementation of Twill platform, customers contacted numerous freight forwarders and followed the shipment via emails, phone calls, involving paper administration. Contingencies caused even more communication, higher costs and delays. Twill platform enabled a customer to check the status of shipment and add documents regarding the shipment. Twill platform creates a centralized database of documents, notifications, conversations, etc., to provide all relevant information about each shipment in real-time and available to all stakeholders involved. Twill system allows placing a booking instantly – 80 % of bookings are completed within 3 minutes, and 30 % within 1 minute [1].

Digital technologies can make seaport services more flexible and simpler for the users. For example, Blockchain technology enables simple, efficient and secure payment. The Port of Koper has tested "CargoX Smart Bill of Lading" [35], for shipment from the Port of Shanghai to the Port of Koper. The B/L is processed through the system in only a few minutes instead of a few days without Blockchain technology. The Port of Rotterdam established a new research and development facility called the "Rotterdam Additive Manufacturing LAB (RAMLAB)" for 3D printing technology in business [31]. The 3D printing enables the Port of Rotterdam to immediately meet the requirements of shipping companies in case of possible malfunction or damage (e.g. damaged propellers). IBM's cognitive IoT technology is a part of this process; it uses a robotic welding arm to apply high-quality metal layer-by-layer to create ship components such as propellers, on-demand and faster. The traditional manufacturing process of a ship component usually takes 6 to 8 weeks while 3D printing needs just 200 hours [31]. Use of the 3D printing can significantly contribute to the port quality by eliminating delays in case of damage on a ship [31].

Secure seaport services could also be provided through implementation of digital technologies. At the APM Terminal in Chile, drones are used to monitor loading and unloading operations, traffic flows and container stack efficiency as well as to observe potential unsafe behaviour (e.g. truck drivers leaving their cabins) [47]. The Nautical Control Center of the Port of Hamburg collects information on the conditions of the River Elbe via sensors. Ship traffic in port waters is continuously fed to the centre, which can share this information with all ships to ensure smooth sailing in its waters. The Rail Supervision Headquarters manages rail transport similarly. Digital technologies in seaports enable track and trace of the cargo and secure movement from and to a port. For example, the Port of Antwerp via NxtPort and T-Mining information sharing platforms, improves the control of the process of releasing a container by using Blockchain technology [37]. This Blockchain platform ensures that the right truck driver is given clearance to collect a particular container, without any possibility of the process being intercepted. Furthermore, through a distributed network, the transaction can go ahead only if there is a consensus among all participating parties, thus excluding any attempts of fraud or unauthorized interference. Finally, the platform prevents damage to users and seaports from mistakes in container releasing which can be harmful for the port service quality. The Port of Antwerp tests the possibility of drones in inspection and controlling a large port area (120 km^2) [23].

Seaports are investing into the digital-based infrastructure and superstructure to ensure quality services. For example, the Port of Rotterdam implemented the "Digital Dolphins", smart quay walls and sensor technology-equipped buoys that support ship-to-ship cargo transfer and generate timely data about cargo status, based on Internet of Things technology – IoT [31]. The "Digital Dolphins" provide insight into the condition and utilization of the berthing terminal, surrounding water and weather conditions, enabling port operators to identify the optimal time and place for ships to dock. Furthermore, the Port of Rotterdam is planning to implement Machine Learning technology to learn from data patterns, so seaport operators will be able to rely on 100 % accurate and real-time data about the seaport's infrastructure [31]. Another project of the Port of Rotterdam is the implementation of digital twin technology to reach the ultimate goal of being the first port in the world to accept autonomous ships [28]. The GIS-powered Digital twin would allow seaport managers to view instantly all operations in the seaport as well as to see the weather conditions, the number of ships sailing, ship speed, etc. Collected information will enable better planning and improved availability of seaport services [30]. The Port of Hamburg uses sensors to monitor the assets (e.g. trucks, cranes, carriers, roads, etc.) and infrastructure (e.g. roads, parking lots, warehouse storage rooms, etc.) to identify recurring underused capacity and make adaptations for optimized utilization (e.g. relocating assets or rerouting goods flows) [39]. The Hamburg Port Authority placed 300 sensors on roads and bridges to track and manage roadway traffic in the port [39]. The Port Road Management Centre provides continuous updates on the status of bridges (open/closed) and traffic throughout the port. This data enables the Traffic Management System to manage the traffic flows to optimize routes, minimize congestions and transit time for all customers. The system automatically adapts traffic lights and digital road signs. Currently, the Port of Hamburg is working on directly forwarding the information to the drivers' smartphones or on-board computers. The Port of Hamburg provides continuous parking space monitoring, gives parking instructions and decreases the possibility of congestion and time to find the parking space [39]. Furthermore, automatic radar identification of ships (AIS technology) and speed detection even imply that traffic management can be done using not only the as-is status of bridges but also the to-be status, which optimizes traffic even further accordingly to predicted delays. Thus, bridges can be planned to open and close just in time, and open only as much as needed for a ship to pass. This could significantly reduce the time spent in the Port of Hamburg while providing port services [39]. Big data analytics over a longer time could enable Port Road Management Centre to improve journey time predictions and plan future traffic infrastructure investments or modifications to optimize traffic flow in a seaport and thus reduce the time necessary to provide port service which will directly influence the port service quality. Southern California, New Jersey, Virginia, Shanghai and Rotterdam in the Netherlands are using automated loading cranes based on Artificial intelligence (AI) [49]. AI enables the cranes to make a decision which container to stack or unload first. In this way, cranes can load and stack loads more efficiently and decrease the time necessary to provide services in the seaport.

Digital skills i.e. ability to use digital technologies, has become an important seaport service quality factor. Digital technologies change the way seaport employees work and collaborate [26]. In the study "Ports of the future", Deloitte provided a survey to estimate the evolution of employees. Survey showed that different profiles of employees will be required in the future so that operational expertise, efficiency and knowledge will be digitalized [21]. Since seaport employees are directly involved in the process of providing seaport services, they should be able to use all the aforementioned digital technologies. Employees with digital skills are able to the full potential of digital technologies to provide quality seaport services. Thus, seaports are investing into education and training of employees. For example, in the Port of Rotterdam trainings are provided to follow the changes necessary due to digitalization. For example, a part of the trainings is directed toward new professions such as Internet of Things (IoT) developer or Big Data Analyst, which are considered as the professions of the future in seaports [45]. At the APM terminal in Brazil, employees are trained to use the Augmented Reality (AR) [41]. Via mobile application, users point their phone at stickers placed on a piece of equipment or on the floor to read the safety information about the location or equipment. In the case of the reach stacker, the app provides details about the safe distance to stand away from the machine while it is in operation. An animation shows the range of motion the machine is capable of and how much space it needs to carry and stack containers in the yard. Another digital marker on the ground shows potentially unsafe areas at the entrance to the terminal area. Previously, the operational layout of some areas of the terminal was only available on paper [41]. Skilled individuals capable of managing operations in a safe and efficient manner within a port, will be a prerequisite. Thus, European port operators also invest significant resources in developing specific training programmes. The future of work in seaports will strive for the minimum of manual labour and the supervision and operation of complex and sophisticated machinery and equipment by using digital technologies [45].

6 Conclusion

Seaport services are raised to a new level characterized by digitalization i.e. the implementation of digital technologies. Upgrading and adjusting seaport services according to the digitalization process becomes important for the seaports to stay productive, user friendly, efficient and competitive. Digital technologies are implemented in different segments of seaport operations: infrastructure and superstructure, cargo handling, intermodal traffic, customs and collections, safety and security, energy and environment. Various digital technologies are available to seaports and the choice depends on the aims of each seaport. Seaports mostly combine a few digital technologies since they are interconnected.

Seaport service quality factors are not uniquely defined. Thus, they should be revised taking into consideration the issues which currently influence seaports, with special emphasis on digitalization. Referring to seaport services, seaport stakeholders and digital technologies, seaport service quality factors could be defined as follows: reliability, flexibility, security, digital-based infrastructure and superstructure and digital skills. Reliability is fundamental as accurate and timely operations of everyone involved in providing services affect the seaport service quality directly. Flexibility of seaport services is focused on approach to users to provide them services according to their needs and enable simpler processes. Security implies unobstructed process of providing the seaport services, barren of any internal or external threats. Digital based infrastructure and superstructure eliminates possible bottlenecks in service providing, since loading and unloading operations affect the whole process. Employees with digital skills are an important part of the overall service quality since employees are directly involved in the process of providing seaport services. Each seaport service quality factor can be observed separately, but it is only their synergy that creates a comprehensive quality of seaport services.

Seaports are already implementing digital technologies, aware of their importance for service quality and competitiveness among other seaports. For example, the Port of Rotterdam is considered as one of the most digitalized seaports. The Port of Rotterdam uses sensors on seaport infrastructure and superstructure to monitor the status and to gather data via the Internet of Things (IoT), with the final goal to improve processes and seaport service quality. Furthermore, the Port of Rotterdam provides 3D printing for users to respond to their specific needs in case of damages e.g. damaged propellers. Digital twin technology is tested by the Port of Rotterdam to make digital replicas of real physical processes and assets to improve them. Also, the Port of Rotterdam is testing the Machine Learning technology to learn from data patterns, so seaport operators will be able to rely on 100 % accurate and real-time data about the seaport's infrastructure. Blockchain technology is tested for simple and secure payment procedures, e.g. the Port of Koper. Cloud platforms are used to increase reliability since this depends greatly on stakeholders (e.g. logistic operators) and their operations, making seaport services more reliable. Artificial intelligence (AI) and Augmented Reality (AR) are also used in seaports to contribute to service quality. For example, Artificial intelligence (AI) enables cranes to make decision which containers to stack or unload first, while Augmented Reality (AR) provides details about safe distance for reach stacker to stand away from the machine while it is in operation through a mobile app. Not only are seaports implementing digital technologies, but they are also aware of the importance of training and education of employees to use digital technologies to achieve seaport service quality. It is expected that in the future, seaport service quality will be determined by digitalization and more digitalized services will be implemented.

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