

Adoption of Digital Technologies to Enhance Port Competitiveness in Maritime Trading Value Network: Future Research Directions through a Systematic Literature Review

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ABSTRACT

Maritime trading is creating a critical transition to enhance the value network through digitalization in the global supply chain. As a node in this chain, ports should play their role effectively and efficiently in value creation in a sustainable manner. Digitalization is adding a new version with considerable changes in the trading environment. These technological changes establish a more collaborative, innovative, and sustainable business. Many researchers have been more concerned with the usage of technological applications than the future trends for enhancing port competitiveness. Competing abilities depend on well-thought-out planning and directing to achieve organizational goals while maximizing customer satisfaction. Therefore, this research objective is to identify the future directions of digitalization to strengthen the port's competitiveness. This objective is addressed using the systematic literature review (SLR) method, which makes the final results consider evaluated articles on emerging digitalization and port competitiveness concepts. For that, article sources were MDPI, Springer, and Emerald Insight, which were published during 2022–2023. Mainly, it was evaluating 60 articles for this research after scrutinizing 144. Those have been given open access and conducted peer review. This research found five major future directions in view of the positive relationship between digitalization and port competitiveness. It is helped by the identification of the characteristics of digitalization and port competitiveness. Their interrelationship guides identify the prominent future requirements of maritime trading: innovations, enhancing stakeholder networks, balancing port sustainability and commerciality, increasing the involvement of maritime institutions, and real-time information flow. The boundary line of these directions is interconnecting each direction. Especially currently, port activities are operated through sustainability initiatives, and economic, social, and environmental strategies are based on the whole range of external and internal environmental factors of the organization: political, economic, environmental, social, technological, and legal. Meanwhile, research has concluded that balancing sustainability and commerciality is the most important of these directions. Future research should be more concerned about these aspects due to the outcome of the sustainable port operation, which creates a win-win situation for each stakeholder in the network.

Keywords; Port Competitiveness, Digitalization, Maritime Trading, Sustainability, Future Directions

INTRODUCTION

In the eco-system, digitalization is not a single technology, and more than a hundred technologies are working together to maximize the supply chain. Technology has spread throughout the entire process of maritime trading, making it very comprehensive and widespread over the global supply chain. It is challenged by the new business environment and digital transformation (Othman & El-gazzar, 2022). Maritime logistics entrust the importance of port management and the efficiency of maritime transportation (Monzon, Baeza, & Ortiz, 2022). Port supply chains play a pivotal role in the process of global economics (Liu et al., 2022). Also, sustainable development and competitive advantage entrust technology to provide solutions for the changing environment (Othman & El Gazzar, 2022).

Traditionally, determinants affecting port competitiveness have been studied and employed to draw the most important conclusions. Major associated determinants of the port can be identified as geographical location, infrastructure, and services that have the capacity to compete and collaborate with other ports (Russo & Musolino, 2021). Relatively recently, Hales et al. (2016) highlighted the necessity of considering the current trends and circumstances in the shipping industry when measuring port competitiveness. Meanwhile, this has become the basement for taking advantage of the port management. Such as enhancing connectivity and sustainability of ports, usage of renewable energy, increased air quality, zero carbon emission practices, reducing greenhouse gases, and observing, monitoring, and managing the practices of sustainability (Sankla & Muangpan, 2022).

In recent years, a new pillar has emerged: emerging technologies (Russo & Musolino, 2021). The focus of innovation is on digitalization, which will make ports more automated, environmentally friendly, and collaborative (Heikkilä et al., 2022). Also, port management and technology have been major driving forces in establishing green competitiveness, which can be identified due to greater usage of the technology by the ports (Kuang et al., 2023). Jun et al. (2018) have mentioned that those ports can be considered autonomous ports, robotic ports, and intelligent ports. Meanwhile, this innovative place improves operational efficiency through information and communication technology, improves the quality of life, and increases port competitiveness. That means it ensures the needs of current and future generations, considering the environmental, economic, and social dimensions (Othman et al., 2022).

The efficiency and effectiveness of the port community system can be increased by emerging

technologies. Innovations and sustainable goals create greater control over global logistics. As an example, the One Belt, One Road (OBOR) infrastructure program has been supported by Chinese companies. Therefore, this transformation impacts not only national but also international politics (Heikkilä et al., 2022). Also, 5G technologies can enable innovations and make the bridge between the SDG and key performance indicators (KPI) of the port (Cavalli et al., 2021). Moreover, in 2019, Singapore port was named "Best Seaport in Asia" while benchmarking for the global green ports as "Best Green Port," and this port is regarded as the model for sustainable port and strong port development (ESCAP, 2021). Therefore, technological advancement, including digitalization, enhances the sustainability and competitiveness of the port (Cavalli et al., 2021).

The innovations of the global supply chain have been influencing port competitiveness in maritime transportation. The prime characteristic is that productivity-based decisions have been made by the partners of this chain, adding value throughout the network. This competitiveness has evolved through the sustainable activities of the shipping industry. Meanwhile, technology is envisaged as a key driver for the sustainable transition of the port. Also, they are enhancing their competitiveness not only through advanced technology but also by investing in infrastructure development, reducing cost and price, improving hinterland connectivity, service quality, green port activities, training and development, etc.

Scientific and professional literature shows the growing interest in the concepts of digitalization, smart ports, and determinants of port competitiveness due to the rapidly spreading of the applications of technology in the port industry. The digital transformation produces recognition from the customers, improves efficiency, builds relationships with customers, and ensures sustainability (Kuo et al., 2022). It also facilitates to community play on a single platform, supporting each other through the sharing of real-time information (Caldeirinha & Nabais, 2022; Serra et al., 2022).

Relationships among stakeholders (port authorities, ministry, harbormaster's offices, freight forwarders, agents, by adapting technology (Aksentijević & Tijan, 2022; Cil et al., 2022; Jović et al., 2022). And it helps with monitoring and traceability to identify the cargo movement (Zhou et al., 2022), ensure the security of maritime trading (Serra et al., 2022), mitigate the human-related risks, threats, and vulnerabilities (Ibrahim, 2022) and it will reduce the manpower requirement and improve fuel consumption with efficient service (Farah et al., 2022). Port efficiency and competitiveness are interconnected terms (Li et al., 2022).

Competitiveness is related to a port's performance in providing value-added goods and services to its customers (Gleser et al., 2023). It focuses on profit maximization and high service quality. Digital transformations improve port operations efficiency, customer relationships, and sustainability. This is facilitated by shipping professional organizations and associations and port authorities (Kuo et al., 2022).

The importance and competition of the regional port have increased during the past few years. More than 80% of the operations of the Colombo port are relevant to transshipment. According to the Frontier Technology Readiness Index (Table 1.1), Sri Lanka will be ranked 89 in 2022 (UNCTAD, 2023). Comparing with regional countries, Sri Lanka is lacking. Digitalization has been adapting to their port activities. It has been creating a critical environment for maritime trading through the booming competitiveness of Colombo port.

Table 1: The Frontier Technology Readiness Index (Rank) – 2023

Country	2023	2021
Singapore	3	5
Malaysia	32	31
United Arab Emirates	37	42
India	46	43
Saudi Arabia	47	50
Indonesia	85	82
Sri Lanka	89	86

Source: (UNCTAD, 2023)

Meanwhile researches should give the future direction to enhance competitiveness through digital technologies due to the uncertainty of the ecosystem. Therefore, this article presents a comprehensive review of the scientific literature on digitalization and port competitiveness and various directions to enhance port competitiveness. Accordingly, this paper is divided into five sections: description of the port's competitiveness and importance of the study: a description of the systematic review methodology: synthesis and result analysis, making scenarios, and drawing conclusions.

PORT COMPETITION AND ITS IMPORTANCE OF THE STUDY

Port competition is a critical topic in transportation economics. This is due not only to the large

volumes of goods involved in port throughput a direct measure of a port's competitiveness but also to induced effects in terms of employment and investment (Meersman et al., 2010). Verhoeff (1981) defined port competition under four levels of seaport competition: competition between port undertakings, competition between ports, competition between port clusters (a group of ports in close proximity with common geographical characteristics), and competition between ranges (i.e., ports located along the same coastline or with a largely identical hinterland).

Productivity is one of the major factors in the port industry for developing competitiveness and market potential. Many factors of competitiveness are affected by this productivity enhancement (Kuo et al., 2020). According to Scaramelli (2010), competitiveness is related to a port's performance in providing value-added goods and services to its customers; in doing so, ports pursue not only economic values, such as profit maximization but also non-economic values, such as improving service quality to secure customer loyalty. He has mentioned that competitiveness does not equal productivity, and neither does productivity equal competitiveness.

Currently, port competition is concerning from an economic, social, political, and business perspective. Therefore, the shipping industry has faced a complicated situation and accelerated competition for the hub port selection process (Kuo et al., 2022). Among these criteria is the indirect impact of technology on operational efficiency (Kavirathna et al., 2018). According to Kaburu (2022), they discovered that digitalization increases efficiency and shortens operations processes, implying that there is an indirect relationship between digital maturity level and port choice.

Therefore, identifying the success of competitiveness is very important for future planning. Port authorities and terminal operators are required to identify this instead of shipping lines as the major customer (Kavirathna et al., 2018). In developed countries, the government is involved in enhancing the port's competitiveness (Wahyuni et al., 2019). Supply chain optimization depends on efficient port operations. Large port users' influence depends on their agenda (Kuo et al., 2022). Therefore, government involvement is necessary to make the port sustainable by addressing the gaps between legislation and implementation (Wahyuni et al., 2019).

METHODOLOGY

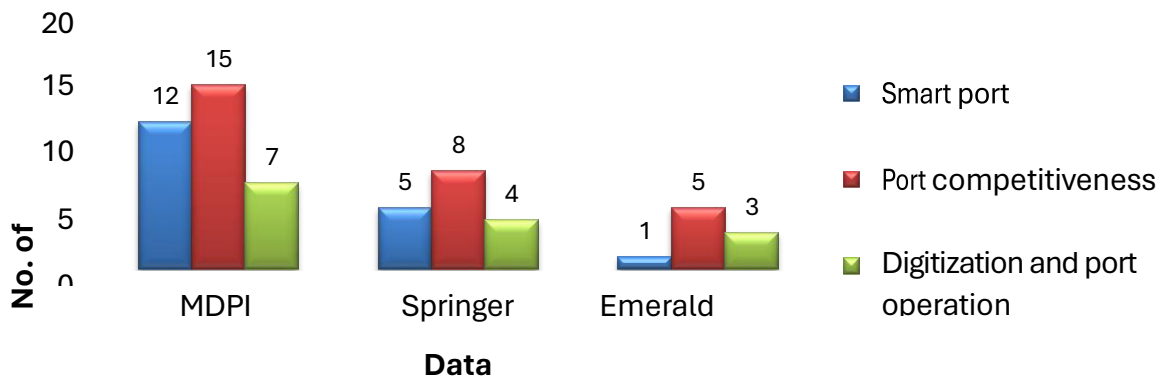
This study aims to examine the literature on digitalization and port competitiveness. For it, researchers used a systematic approach following Denyer & Tranfiel (2009). They have proposed five steps for the systematic review: (1) review and formulation of the research question; (2) location of studies; (3) selection and evaluation of studies; (4) analysis and synthesis; and (5) results presentation.

In the first step, the researcher identifies the port's competitiveness and digitalization. Second step: identify the previous studies and search scientific data bases. In this literature, article sources were MDPI, Springer, and Emerald Insight, which published during 2022–2023. Those have given open access and conducted peer review. As the third step, the researcher ensured the quality and transparency of the selection of the literature using a set of inclusion criteria mentioned in Table 2 and Figure 1.

Table 2: Criteria

Criteria	Definition of the criteria	Criteria included
Language	Internationally recognized article	English
Research period	Article identifying period	02 nd to 05 th of April 2023
Type of items	Aim for quality of published articles	Peer-reviewed scientific articles
Publication period of the articles	Period consider the concepts are Emerged	January 2022 to April 2023

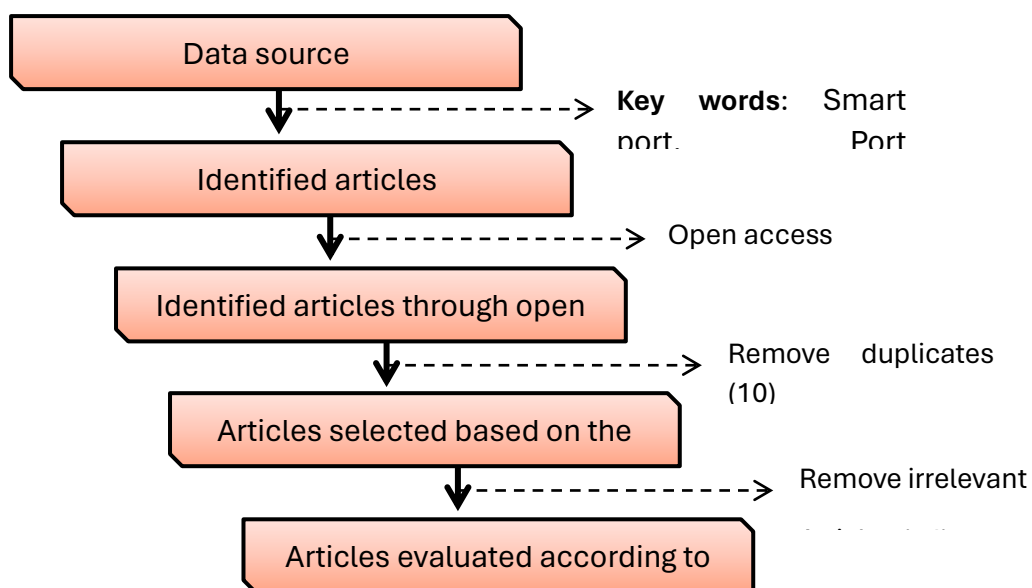
Figure 1: Data Source Wise, Distribution of Evaluated Article



According to key words "smart port", "port competitiveness" and "digitization and port operation", details of article selection are illustrated in Figure 2. The Web source indicated 2119 files, but only 144 had free access to download. Then the researcher analyzed the remaining 134 articles after removing the 10 duplicates. This analysis enabled him to select articles that aimed to provide an understanding of the digitalization and port competitiveness concepts based on the title of the article and the abstract. Finally, 60 articles were selected for this research for literature analysis.

The fourth step analyzes and synthesizes selected studies to highlight emerging digitalization and factors of competitiveness for an overall understanding of the concept, and finally classifies characteristics defined in the literature. Based on these characteristics, scenarios for future directions were identified.

Figure 2: Identify, Selection and Evaluated Articles



LITERATURE REVIEW

Digitalization in Port Operation

Port supply chain plays a pivotal role in the process of global economy (Liu et al., 2022). Maritime logistics entrust the importance of port management and the efficiency of maritime transportation to decarbonization (Monzon Baeza & Ortiz, 2022). Many research studies mentioned the rapid growth of technology during the past few years as part of maritime logistics (Iman et al., 2022). The new business environment and digital transformation have been challenging the global supply chain, and adapting new technology can address these challenges (Othman & El-gazzar, 2022).

According to UNCTAD (2023), new technologies in trading can be identified under the 16 categories of technologies. Table 3 shows the digitalization of maritime logistics.

Table 3: Usage Digitalization Approaches in the Maritime Logistics

Author	Usage of Digitalization
<i>Heikkilä, et al., (2022)</i>	Applications of Smart port 4.0: renewable energy, hybrid, electric based terminal equipment and container tracking system
<i>Alamouh, et al., (2021)</i>	Digitalization – single window system, port community system which give service to ship and land transportation for other users also. E-document management system (EDI –Electronic Data Exchange, E-document program, RFID). Technologies for connectivity and analysis of data (IoT, big data, cloud and edge computing). Block chains (digitalized ledger system, e-bill of lading). Measures of cyber security
<i>Sankla & Muangpan, (2022)</i>	Smart port applications for environment, economic and social aspects.
<i>Jun, et al., (2018)</i>	Practices of smart ports; environment, energy, operational, safety, security, people factor
<i>Sankla & Muangpan, (2022)</i>	Internet of Thing (IoT) – exchanging of information about the climate, position, sea route and specifications of cargo. Big Data (BD) – for the purpose of analysis of low enforcement and cargo owner, shippers etc...

	Block Chain (BC) – facilitates the monetary transactions between the stakeholders and digital legalization
	Artificial Intelligence (AI) – space allocations, security detection and actions, allocations of containers automatically
	Digital Twin – interface and simulations of physical movement and live seen
<i>Mudronja, et al., (2022)</i>	Drones, G networks, fuel technology, internet of Vehicles etc...

Source: Developed by author

Digital transformation gives many benefits to maritime shipping (Kuo et al., 2022). It produces recognition from the customers, improves efficiency, and builds relationships with customers and sustainability and digitalization facilitate community play on a single platform, supporting each other through the sharing of real-time information (Caldeirinha & Nabais, 2022; Serra et al., 2022). It helps monitor the visualization and audibility of terminal and yard operations (Cil et al., 2022 ; Zhou et al., 2022), and identify container movement in the global (Aksentijević & Tijan, 2022), mitigate the human-related risks, threats, and vulnerabilities (Ibrahim, 2022), and ensure the security of maritime trading (Serra et al., 2022).

Directions of Digitalization

According to the literature, researcher could identify the various approaches to digitalization and their benefits for maritime transportation and other logistics services. This research aims to identify the future directions of digitalization to enhance port competition. Considering the various approaches, researcher could identify the current and future directions of digitalization through various empirical evidence. However, any research has not demarcated these directions, and many of the directions are interconnected. Information flow can be achieved through automation and traceability. Safety and security require better information flow and connectivity. According to Iman et al. (2022), the rapid growth of technology during the past few years has become a part of maritime logistics. Therefore, directions have been changing from time to time according to the digital transformation.

Further, Othman & El-gazzar (2022) have mentioned that the new business environment and digital transformation have been challenging to the global supply chain and that port users need to address these challenges by adapting new technology and smart management. Considering this phenomenon of the technology and business environment, researchers have identified

major directions from previous research. Such as innovations, connectivity, and information flow; environment management system, safety and security, sustainable initiatives of the port, commerciality, and maritime institutions.

Innovations

According to Bhandari, (2022) technology is a vehicle to drive supply chain competitiveness and performance through improving the overall effectiveness and efficiency of the logistics system. And facilitate prosperity in individuals, businesses, and nations (Chebo & Wubatie, 2021). Also, various types of technology can make tasks easier and faster for the customer with the minimum number of workers. Specially, in today's digital era, businesses need to be agile and adaptive. With a plethora of affordable technologies now available, it has never been easier to build modern architecture by composing various services. Further, they have mentioned that the direct and indirect effects of technology adoption, innovation, and diffusion on value creation and competitive advantages will be a novel contribution to the study of such a relationship. With this technology, key changes have been happening in maritime logistics. Such as innovations in port operation and shipping transportation (Farah et al., 2022; Tsvetkova & Hellström, 2022),

Bhandari, (2022) has highlighted that emerging new technologies provide strategic opportunities for institutions and organizations to develop their competitiveness in various management fields, including logistics and supply chain management. He has categorized this innovative technology into three categories: automatic identification technology, communication technology, and information technology.

Innovation makes ports more automated, environmentally friendly, and collaborative. It is emphasized by the environmental, social, and economic aspects of smart ports (Sankla & Muangpan, 2022). Amarathunga (2022) has mentioned the configuration of an automated port as seaside, quayside, and landside. It consists of quayside automation, horizontal transport (seaside), yardside automation, horizontal transport (landside), and gate automation. Terminal automation mainly focuses on transportation, yard automation, and quayside areas (Amarathunga, 2022). Such technology is used for automated guided vehicles (AGV), automated rail-mounted gantries (ARMG), automated and unmanned tractors, runners, cranes, shipping equipment to shore, equipment in the yard, and container movement from berth to yard. Also, they have used various technologies for that, such as radio frequency identification

(RFID) and optical character recognition (OCR) (Knatz et al., 2022).

Automation has been increasingly used by global ports due to its ability to improve the efficiency of the port and fulfill the requirements of maritime trading (Amarathunga, 2022). Declining business development urgently requires automation, and as a result, management has been concerned about the automation of the terminal (Amarathunga, 2022). The top twenty ports have been automated at a certain level, it increases the frequency of container movement and reduces unwanted cargo handling and movement. That means it gives optimal cargo handling through automated equipment and analysis programs (Rodeigue & Notteboom, 2021).

Another example is the single window system. Singapore's National Single Window for Trade Declaration is Trade Net. It provides a single platform for Singapore's trade and logistics community to meet all regulatory requirements related to import, export, and transshipment. TradeNet reduces the cost and time required to prepare, submit, and process trade documents by providing a single point of entry for the submission of a single declaration to multiple regulatory agencies.

In addition to that, composable technologies are a major innovation in the port industry. It allows companies to seamlessly integrate and automate their workflows across different platforms. Composable technology means building on the digital core that companies have in place to power their businesses, quickly incorporating required new or enhanced capabilities through additional applications and allowing for easy integration (McGuigan & McKillips, 2022). Businesses can decipher the data required to make better, faster decisions by connecting these platforms and applications, running them in the cloud, and adding an advanced data integration layer. Composable (modular) technology shortens transformation time by leveraging proven, repeatable solutions that can be configured and reconfigured quickly to address changing business needs and pave the way for rapid value realization.

Connectivity

Relationships between stakeholders: port authorities, ministries, harbormaster's offices, freight forwarders, agents, and terminal operators can be enhanced by adapting technology (Jovic et al., 2022). Most of the port recognizes the importance of not only investing in infrastructure but also smart technologies and integration within the port community (Othman et al., 2022). Digitalization integrates all the parties into a single port and connects all the ports (Farah et al.,

2022). Also, it makes bridges, gives power (Liu et al., 2022), reduces costs, and enhances the maritime supply chain's efficiency (Gavalas et al., 2022; Liu et al., 2022).

As an example, the terminal operating system provides tracking facilities for cargo movement while all parties are aware of all the container data in real-time (Othman et al., 2022). This real-time tracking technology improves connectivity, procedures, and function ability throughout the port administration and cargo owners. It reduces cargo delays and increases efficiency between shipping lines and ports. Tracking is also important because it verifies that the correct container is loaded into the correct vessel at the right time. That means actual data can be identified. Also, logistics service providers, freight forwarders, and container warehouses are other information users in this supply chain (Rodeigue & Notteboom, 2021).

Barcodes and global positioning systems give better information about shipping and cargo movement by enhancing supply chain performance, utilization rates, and container cycle volume (Calatayud et al., 2020). Cargo passes various ports and a variety of stakeholders who need information about cargo location, reasons for delay, and arrival time. Because they are not actively participating in container handling (Rodeigue & Notteboom, 2021).

Information Communication System (ICT):

The flow of goods (cargo), information, and finance can be efficiently and effectively transferred within the decision-makers through ICT as a single-port operation. It helps to make decisions for the different decision-makers (Russo & Musolino, 2021). ICT gives a better interface with stakeholders, assisting them to maximize the bottlenecks, plan well, and achieve the expected gains from international trade (Calatayud et al., 2020). Another important thing is that it guarantees information's relevancy, integrity, and consistency through the sharing and storage of information. And it gives a better economic outcome through better decision-making supported by an information system (Knatz et al., 2022). Also, the information system automatically gives safe guidelines for operating ships with the correct position, speed, path, route, and course (Tran, 2022).

Scanners and positioning systems provide better control of the terminal by effectively transferring information and helping to move the automated trucks. It helps to work at night without any accidents is harmless to the people, reduces labor costs by 70 percent, and increases efficiency by 30% (Koroleva et al., 2019). Another important concept is the single-window concept. All the stakeholders in the chain exchange information in real-time, which improves

the business process and sustainable development (Mudronja et al., 2022). Rotterdam port: IoT sensors, AI, and augmented intelligence give weather data in real-time, berth availability, and other parameters to carriers, reducing the stay time and increasing the loading and unloading volume and efficiency of the terminal operation. As a result of more vessels adopting the system. Digital dolphins clear the port from traffic congestion and make space for optimal utilization of trucks and ships at the port.

5G is also providing benefits for port users through a real-time and high-speed data transfer system. It is helping the functioning of other technologies and equipment. Such as automated vehicles and IoT, which provide efficiency in operation and transparency for the activities. Also reduces cost and waiting time, increasing traffic safety, which helps to achieve sustainable developments (Mudronja et al., 2022). Block chain also improves the efficiency of the storage system and freight document and data transfer. It improves the visibility of the entire supply chain (Mudronja et al., 2022).

Container terminals have been utilizing information technology for better management. It helps to manage the assets and provide alternatives for the human job role. Such terminal operating systems (TOS) facilitate control, maximizing movement and storage in the terminal area. Also, they have been using RFID, OCR, and anti-sway systems for that purpose (Knatz et al., 2022).

The prime characteristic is that productivity-based decisions have been made by the partners of this chain, adding value throughout the network. This competitiveness has evolved through the sustainable activities of the shipping industry. Meanwhile, technology is envisaged as a key driver for the sustainable transition of the port. Also, they are enhancing their competitiveness not only through advanced technology but also by investing in infrastructure development, reducing cost and price, improving hinterland connectivity, service quality, green port activities, training and development, etc.

Environment Management System (EMS):

Environmental degradation occurs through maritime activities. Smart ports highlight the importance of the role of a variety of indicators in economic, social, and environmental performance. Those indicators provide benefits for all the stakeholders in maritime logistics by achieving environmental objectives (Othman et al., 2022). Smart and sustainable port operations ensure functions related to economic, environmental, and social smart ports (Sankla & Muangpan, 2022).

Specially smart ports ensure lower emissions, pollution, and consumption of energy (Othman et al., 2022). It is important to maximize the use of natural resources, space, time, and finance to create energy and operational efficiency and establish environmental sustainability. Hence, the inclusive performance of the port can be increased by the smart port. Automation and connectivity mainly help reduce environmental pollution (Othman, Gazzar, & Knez, 2022; Sankla & Muangpan, 2022). Applications of ICT help not only with connectivity and collaboration but also with environmental friendliness and energy efficiency in freight transportation (Evangelista et al., 2018).

Safety and Security:

Ports are facing vulnerabilities in safety and security matters. Digitalization can solve these problems, ensure productivity, address environmental aspects, and use energy efficiently (Othman et al., 2022). Digitalization facilitated efficient supervision of the port area and better identification of the persons, equipment, and treats, which can be further analyzed through ICT (Rodeigue & Notteboom, 2021). Smart port impact on productivity, value-added services, and employment as a result, all parties can ensure cargo movement is safe without any internal harm and ensure the safety of the employees (Rodeigue & Notteboom, 2021). Applications of smart ports in Egypt could ensure the safety and security of the ship, solving the uncertainty in the trading pattern (Othman et al., 2022).

Sankla & Muangpan (2022) mention the safety of workers, the security of the port, and the community as the social aspects of the smart port. It has an impact on boosting the activities of the port, which ensure best practices and create recognition through the implanting of digitalization tools. Block chain also improves the efficiency of the storage system and freight document and data transfer. It improves the visibility of the entire supply chain. Further, it helps to minimize human errors by minimizing waste, fraud, and theft, providing tracking facilities, cost reduction, eliminating time delays, and saving time and other resources. which help to achieve sustainable goals (Mudronja et al., 2022). IoT provides facilities for storage and monitoring of the data. Also, RFID and camera-built technologies ensure the safe handling of cargo while minimizing the time. However, those are very extensive facilities and face cyber-attacks, which are vulnerabilities of ICT (Kosiek et al., 2021).

Sustainable Initiatives of the Port

Sustainable initiatives are defined clearly by the American Association of Port Authorities (AAPA) as strategies, policies, and actions that meet the needs of present and future stakeholders of the port while ensuring the protection and sustainability of natural and human resources (Degens, 2008). Most industries in the world have been facing novel, unpredictable, and extraordinary challenges. As a result, operational decisions made by them are liable, accountable, and reflect sustainable initiatives (Cavalli et al., 2021). Sustainable initiatives are required for the maritime business as an emerging trend in the shipping industry. As a result, port authorities have been influenced to adapt this green governance practice in the port (Jugovic et al., 2022).

Port stakeholders have been implementing a variety of measures to enhance the port's sustainability and meet the challenges of social, economic, and environmental conditions (Hossain et al., 2021). Therefore, these three dimensions are most important when pursuing sustainable development in the port (Cavalli et al., 2021). On the other hand, port sustainability is an international obligation that is programmed as the Sustainable Development Goals (SDG) promulgated by the United Nations (Jun et al., 2018).

Increasing trade flows require port development, which drives economic growth. Port authorities need to increase port expansion and infrastructure development while meeting economic, social, and environmental objectives and goals (ESCAP, 2021). That means while reducing environmental negative impact and improving social welfare, ports need to operate with higher economic performance (Sankla & Muangpan, 2022). WPSP (2020) mentions the main five areas covering the activities, responsibilities, and competencies of port participants. Such as strong infrastructure, community and stakeholder participation, safety and security, governance, and ethics.

Commerciality

According to the dictionary, the meaning of commerciality is commercial quality or character; ability to produce a profit. It helps to maximize the returns of the business. One important thing is that the company should have a better understanding of the other parties in the network. They should have better knowledge about the issues and problems and, ultimately, should provide advice to achieve their objectives and outcomes. It is a deeper understanding of the customer's environment, challenges, market impact, business strategy, their audiences, political and legislative implications, and a whole host of commercial activities. Through the network, it

provides first-class service, enhances competitiveness, and ultimately achieves business goals. Therefore, credibility is important for not only retaining customers but also making a huge profit from their demand.

Maritime Institution

Global institutions, professional organizations, and associations provide support to digital transformation by providing consultation and funding (Clott & Hartman, 2022), and the social network has initiated the promotion of sustainability (Vitellaro et al., 2022). Shipping professional organizations and associations are providing standards, guidelines, and recommendations for the shipping industry considering the new trend of the digital transformation (Kuo et al., 2022).

As an example, UNCTAD has been implementing trade facilitation and promotion programs around the world. Through this intervention, they increase knowledge, raise funds for the project, and guide the achievement of the sustainable development goals. Therefore, private and government, local, regional, and global government and non-government organizations and institutions make their programs and implantations to ensure the smooth functioning of the global supply chain. Also, universities and education institutes are arranging programs to develop the duration of maritime logistics. Such as World Maritime University, Lloyd Institution, etc.

Port Competitiveness

Port and maritime transportation have a positive and significant relationship (Igemohia & Faghawari, 2022). Enhancing the efficiency and competitiveness of the port are critical concerns in maritime transport (Mouafo Nebot & Wang, 2022). Competitiveness has always been used as a comparison to provide two or more things (Rozar et al., 2022). In this context, efficiency and competitiveness are more closely associated with maritime logistics. Economic development and proper management of the port realize the high efficiency of the port and its influence to direct the economic development of the hinterland and enhance the import and export trading competitiveness (Li et al., 2022).

In the current maritime trading scenario, factors affecting competitiveness vary according to the port users. Scholars and professionals have identified those factors in different ways. For instance, Tijan et al. (2022) have identified these determinants as geographic location, feeder connection, maritime connectivity, superstructure and infrastructure facilities of the container terminal and the port, length of the berth, depth, hinterland connectivity, reputation, cost,

custom procedure, and ICT systems.

Wagner et al. (2022) have mentioned that the cost of the operation, the security of the chain, and the low carbon emissions through the chain are important attributes of the chain. The selection process may differ for perishable items such as fruits and vegetables (Mohseni et al., 2023). Also, governance practice (Gracia et al., 2022), new facilities and infrastructure (Wagner et al., 2022), consolidation of multiple terminals, terminal size, and low energy consumption and low pollution equipment handling (Jiang et al., 2023), cost reduction (Jiang et al., 2022), adaptation of port access infrastructure (Wagner et al., 2022), and efficient maritime container terminals enhance the port's competitiveness (Ambrosino & Xie, 2022).

Sufficient government funds, high tertiary commerce, good economic development, and openness of the market are critical conditions required to maintain high port competitiveness (Huang et al., 2022). Also, inter-ports (Bernacki & Lis, 2022) and relations between two countries play a predominant role in shaping competitiveness (Tsantis et al., 2022). Customer preferences influence maritime trading in various ways, creating an opportunity to expand the value network of maritime trading (Zhou et al., 2022). Maritime transport financing enhances the total trade flow to the country and the port (Matekenya & Ncwadi, 2022).

Port users and supply chain participants' roles are important to building the Port Community Systems (PCS). It determines productivity, efficiencies, and competitiveness while improving the port's attractiveness through better connectivity (Mthembu & Chasomeris, 2022). The integration of the core players—ports with inland logistics providers and government intervention—and the integration of new technologies (Lin & Chang, 2022), green competitiveness (Kuang et al., 2023) and hinterland connectivity (Gleser et al., 2023) can improve the efficiency and resilience of the maritime supply chain.

New technology enhances the sustainable development and competitive advantage of the port business (Othman & El Gazzar, 2022). Digitalization will deliver the greatest benefits to maritime trading to improve the port's competitiveness: improved efficiency, relationships with the participants in the network, and sustainability (Kuo et al., 2022). Autonomous container truck help to minimize the energy consumption, level of manpower, reduce the cost, and improve the service efficiency (Farah et al., 2022); Hong et al., 2023). TOS (Terminal Operating System) can manage the real-time storage and flow of the cargo between the transport nodes (Ambrosino & Xie, 2022). Government-owned companies (GOCs), such as

ports, make the strategies and policies considering port sustainability (Barreiro-Gen et al., 2022). The consideration of technology makes a difference when port size is different, which is important to maintain green competitiveness (Kuang et al., 2023). New mega containers require advanced port technology facilities, which create demand among these shipping owners (Wagner et al., 2022).

Relationship between Digitalization and Port Competitiveness

Spreading of digital trade has a greater impact on service trade which than the merchandise goods trade (ESCAP, 2016). Technology can be considered as a vehicle to enhance the competitiveness and supply chain performances through improving the logistics services' efficiency and effectiveness. Also, directly and indirectly, it affects value creation and creates competitive advantages (Bhandari, n.d.).

Digitalization delivers greater benefits to maritime trading to improve port competitiveness: efficiency, relationships with the participants in the network, and sustainability (Kuo et al., 2022). Smart port, technology, and sustainable performance have a relationship, and they address the issues efficiently in maritime logistics (Othman et al., 2022). As part of this, artificial intelligence, big data, and automation can improve the efficiency of the port's operational status and make it more competitive (Lin & Chang, 2022).

Mthembu & Chasomeris, (2022) has mentioned role of the port users and other stakeholders are important to develop the Port Community System (PCS). It determines port competitiveness, and productivity throughout the supply chain while enhancing the attractiveness through the better connectivity. The integration of the core players, ports with inland logistics providers and government intervention, integration of new technologies (Lin & Chang, 2022), green competitiveness (Kuang, et al., 2023) and hinterland connectivity (Gleser, et al., 2023) can improve the same as mentioned by Mthembu & Chasomeris, (2022) and furthermore supply chain resilience.

Autonomous container trucks help to minimize the energy consumption and level of manpower, reduce the cost, and improve service efficiency (Farah et al., 2022; Hong et al., 2023). TOS (Terminal Operating System) can manage the real-time storage and flow of cargo between the transport nodes (Ambrosino & Xie, 2022). Digital platforms among the port

community exchange and share real-time information. This integration enhances competitiveness through efficiency (Mthembu & Chasomeris, 2022).

Block chain also improves the efficiency of the storage system and freight document and data transfer. It improves the visibility of the entire supply chain. Further, it helps to minimize human errors by minimizing waste, fraud, and theft, providing tracking facilities, cost reduction, eliminating time delays, and saving time and other resources (Mudronja et al., 2022). Also, a single-window system creates a shorter waiting time through the speed of the loading and unloading processes and reduces the cost of the entire process by removing the delay. Also, it enhances communication and the transfer of information among stakeholders through 5G. Therefore, productivity is enhanced in the operation. It generates a large amount of data within a few seconds and makes business processes efficient. Also manage the traffic, improve transparency and safety, and reduce business costs (Mudronja et al., 2022).

Smart Port has created a new logistics system that ensures safety, quickly delivers goods, and has a minimum cost. The most important thing is the increasing influence of efficiency on the recognition and improvement of the port, which is important for the strategic positioning among the ports, future development activities, and investment flow (Koroleva et al., 2019). TOS provides integrated real-time systems and automation that are hosted in the cloud. Also, better visibility and interoperability of the supply chain are provided by digital twins, artificial intelligence, the internet of things, and machine learning. Therefore, it is important to maintain transparency and collective efforts for sustainability (Tran, 2022).

Belmoukari et al. (2023) have mentioned the relationship between digitization and sustainability, which trust digitization due to its providing the solution for changing environments in the global supply chain. Because innovation in port operation and shipping transportation has been complying with sustainability through smart port activities and digitalization (Farah et al., 2022; Tsvetkova & Hellström, 2022). Also, it enhances the green port capabilities (Han et al., 2022; Jugovic et al., 2022).

Tijan et al. (2022) have indicated that sustainable port operations ensure the functions related to three kinds of smart ports: economic, social, and environmental smart ports. As a result, best operation planning gives many benefits, such as improving business sustainability in the port, renewable energy usage, improving social safety and health, managing the environment in the port, decreasing emissions, improving air quality, minimizing greenhouse gas emissions, minimizing water consumption, waste management, electricity consumption, and monitoring

and managing green concepts. Therefore, digitalization gives sustainable portability. On the other hand, these requirements have been seen as an added value to the port charges and costs (Adams et al., 2009).

As a part of smart port initiatives, sustainability initiatives consider sustainable performance through not only port operation but also energy, environment, safety, and security. In the future, digital innovation will make the difference between sustainable development, cooperation, and automation. (Othman & El-Gazar, 2022). As an example, the renewable energy-based hydrogen-based Automated Container Terminal (ACT) has become more famous as the low-carbon transmission system in the port due to the effective usage of clean energy (Yang et al., 2022). Therefore, smart port, technology, and sustainable performance have become necessities for sustainable port operations (Belmoukari et al., 2023).

Considering the ports in the world, the green competitiveness of the port has been enhanced by the port management and the technology. In fact, innovation plays a major role in port sustainability (Kuang et al., 2023). Also, Heikkilä et al. (2022) have indicated that key components of the smart port are automation, collaboration, and sustainability (Sankla & Muangpan, 2022). Automation and connectivity mainly help reduce environmental pollution. Applications of ICT help not only for connectivity and collaboration but also for environmental friendliness and energy efficiency in freight movement (Jiang et al., 2022). Therefore digitalization as the part of innovation creates ports more automated, environmental friendly and collaborative. It is emphasized by environmental, social, and economic aspect of smart port (Sankla & Muangpan, 2022).

Currently, digitalization has become a threat to port operations. Such as stolen goods, illegal activities, cyber-attacks, etc. (Othman et al., 2022). Under this situation, technology has connected the social dimension of the port operation (Heikkilä et al., 2022). On the other side, the implementation of sustainable technologies can make the best practices to ensure the employees safety, the security of the port, and social security. And it creates a good image among the stakeholders (Rodeigue & Notteboom, 2021; Sankla & Muangpan, 2022). Special supervision of the port area, people and objects identification, threat analysis, and cyber security threat analysis have been ensured by the digitalization (Sankla & Muangpan, 2022).

Digital transformation is not an easy task for organizations. It needs skilled staff, and their knowledge is very important. Because of their resistance to change, insufficient knowledge about the process, and lack of coordination among the departments. That need to be solved for

sustainable port operation through technology (Othman et al., 2022). It saves money and time with the shorter processing time and minimizes the environmental impact by reducing the waiting time for loading and unloading at the terminal and yard area. Especially, it uses human resources efficiently through increasing productivity and information exchange (Mudronja et al., 2022).

Furthermore, digitalization influences logistics capabilities such as green logistics, international logistics, and total logistics capabilities (Iman et al., 2022). As a result of stakeholders' concrete new business, new service, and introduction of new channels throughout the network, additional revenue will be generated (Farah et al., 2022) and a win-win situation will be achieved. Therefore, it creates a business opportunity for the stakeholders and the country by improving their customized service in the maritime field for the entire network (Shi et al., 2022).

Kavirathna et al. (2018) mention that identifying the success of competitiveness is identical and significant for future planning. In view of this, major parties such as port authorities and terminal operators need to identify this shipping line as the key customer. In developed countries, the government is involved to enhance port competitiveness (Wahyuni et al., 2019). Supply chain optimization depends on efficient port operations. Largest port users influence based on their agenda (Kuo et al., 2022). Therefore, government involvement is necessary to ensure the port's sustainability through digitalization, addressing the gaps between legislation and implementation (Wahyuni et al., 2019).

RESULTS AND DISCUSSION

Digitalization

Articles mentioned the benefits, characteristics, and applications of digitalized technology for port operations. Table 4 and figure illustrate 10 characteristics based on digitalization that were identified from 32 articles.

Table 4: Summary of the Grouped Digitalization Characteristics

Characteristics	Source
Operational efficiency	(Kuo, et al., 2022), (Gavalas, et al., 2022), (Tsvetkova & Hellström, 2022), (Serra, et al., 2022), (Farah , et al., 2022), (Othman & El-gazzar, 2022), (Othman & El Gazzar, 2022), (Han, et al., 2022)
Maritime logistics capabilities	(Iman, et al., 2022), (Serra, et al., 2022), (Tsvetkova & Hellström, 2022), (Zeng, et al., 2022)
Contribution of maritime institution	(Kuo, et al., 2022), (Vitellaro, et al., 2022), (Clott & Hartman, 2022)
Strategies for digitalization and port sustainability	(Kuo, et al., 2022), (Jugovi´c, et al., 2022), (Akkerman, et al., 2022), (Belmoukari , et al., 2023), (Heikkilä, et al., 2022), (Othman & El-gazzar, 2022), , (Othman & El Gazzar, 2022), (Clott & Hartman, 2022)
Stakeholder connectivity	(Iman, et al., 2022), (Serra, et al., 2022), (Caldeirinha & Nabais, 2022), (Jovi´c, et al., 2022), (Serra, et al., 2022), (Farah , et al., 2022), (Heikkilä, et al., 2022), (Othman & El Gazzar, 2022)
Efficient information flow	(Serra, et al., 2022), (Caldeirinha & Nabais, 2022), (Sahu , et al., 2022), (Serra, et al., 2022), (Li, et al., 2022), (Monzon Baeza & Ortiz, 2022), (Clott & Hartman, 2022)
Automation	(Yang, et al., 2022), (Heikkilä, et al., 2022)
Decarbonize	(Yang, et al., 2022), (Farah , et al., 2022), (Monzon Baeza & Ortiz, 2022)
Monitoring and traceability	(Caldeirinha & Nabais, 2022), (Zhou, et al., 2022), (Aksentijevi´c, et al., 2022), (Cil, et al., 2022), (Hake, et al., 2023), (Li, et al., 2022), (Monzon Baeza & Ortiz, 2022), (Sahu , et al., 2022)
Security	(Ibrahim, 2022), (Tsvetkova & Hellström, 2022), (Serra, et al., 2022), (Farah , et al., 2022), (Han, et al., 2022)

Source: Developed by Author

Mainly four characteristics are highlighted in the eight articles. Those who have mentioned the digitalization influence on port operations are: Operational efficiency, Strategies for digitalization and Sustainability, Stakeholder connectivity and monitoring and traceability. Efficient information flow, security, maritime logistics capabilities, the contribution of maritime institutions, decarbonization, and automation are highlighted in 7, 5, 4, 3, and 2, no of articles respectively. However these distinctions are considered the interrelations of these characteristics such as automation make the low carbon emission terminal operation, equipment etc. And it is impacted by the strategies relevant to sustainability.

Port Competitiveness

All the articles relevant to port competitiveness give a new rather than traditional view of this concept. The term competitive has always been used as a comparison to provide a distinction between two or more things (Rozar et al., 2022). These characteristics can be considered as factors affecting the port's competitiveness, as illustrated in the table 5.

Table 5: Summary of the Grouped Digitalization Characteristics

Characteristics	Source
Terminal operation	(Jiang, et al., 2022), (Mouafo Nebot & Wang, 2022), (Jiang, et al., 2023), (Ambrosino & Xie, 2022)
Digital transformation	(Jiang, et al., 2022), (Lin & Chang, 2022), (Othman & El Gazzar, 2022), (Kuang, et al., 2023), (Hong, et al., 2023), (Iman, et al., 2022), (Mthembu & Chasomeris, 2022), (Gracia , et al., 2022)
Operational efficiency	(Li, et al., 2022), (Lin & Chang, 2022), (Igemohia & Faghawari, 2022), (Rozar, et al., 2022), (Iman, et al., 2022), (Mohseni, et al., 2023)
Maritime shipping network	(Bernacki & Lis, 2022), (Zhou, et al., 2022), (Gracia , et al., 2022), (Notteboomand & Rodrigue, 2022), (SHI, et al., 2022)

Maritime logistics capabilities and service	(Wagner, et al., 2022), (Costa & Soares-Filho, 2022), (Igemohia & Faghawari, 2022), (Iman, et al., 2022), (Ambrosino & Xie, 2022), (Tsantis, et al., 2022), (Notteboomand & Rodrigue, 2022), (SHI, et al., 2022)
Low carbon emission	(Wagner, et al., 2022) (Jiang, et al., 2023), (Hong, et al., 2023)
Sustainable port performance	(Othman & El Gazzar, 2022), (Kuang, et al., 2023), (Barreiro-Gen, et al., 2022)

Source: Developed by Author

Eight articles out of 28 mentioned that both maritime logistics capabilities and services and digital transformation enhance port competitiveness. Operational efficiency and the maritime shipping network are highlighted in six articles. Terminal operation, sustainable performance, and low carbon emission are indicated on 4, 3, and 3 articles, respectively. Sustainable performance and low carbon emission factors are relevant to the sustainable practices of the port and, therefore, need to be considered for future planning and operation of the port. Meanwhile, high port competitiveness consisted of improving logistics capabilities and service, as well as undergoing digital transformation.

Impact of Digitalization on Port Competitiveness

During the identification of characteristics of both concepts: digitalization and port competitiveness, researcher could scrutinize the relationship between these concepts. This impact can be illustrated in the table 6. Meanwhile, it shows the influence of the applications of digitalization to enhance port competitiveness. Such as digitalization, it can improve the operational efficiency of port activities while improving port efficiency. According to Scaramelli (2010), competitiveness is related to a port's performance in providing value-added goods and services to its customers; in doing so, ports pursue not only economic values, such as profit maximization, but also non-economic values, such as improving service quality to secure customer loyalty. Therefore, this illustration presents the direct and indirect impact of digitalization on port competitiveness through the involvement of digitalization in port activities.

Table 6: Relationship with Digitalization and Port Competitiveness

Focus on	Impact on port	Literature
Digitalization	Operational efficiency	(Kuo, et al., 2022), (Gavalas, et al., 2022), (Othman & El Gazzar, 2022), (Farah , et al., 2022), (Han, et al., 2022), (Serra, et al., 2022), (Jovi´c, et al., 2022)
	Digital transformation	(Kuo, et al., 2022), (Othman & El Gazzar, 2022), (Farah , et al., 2022)
	Sustainable port performance	(Othman & El Gazzar, 2022)
Decarbonize	Port operational efficiency	(Farah , et al., 2022), (Monzon Baeza & Ortiz, 2022), (Yang, Meng, & He, 2022)
	Maritime shipping network	(Farah , et al., 2022)
	Digital transformation	(Farah , et al., 2022)
	Low carbon emission	(Yang, Meng, & He, 2022)
	Maritime logistics capabilities and service	(Yang, Meng, & He, 2022)
	Terminal operation	(Yang, Meng, & He, 2022)
Security	Port operational efficiency	(Han, et al., 2022), (Serra, et al., 2022), (Ibrahim, 2022)
Stakeholder connectivity	Port operational efficiency	(Serra, et al., 2022), (Jovi´c, et al., 2022), (Serra, et al., 2022), (Caldeirinha & Nabais, 2022)
	Maritime shipping network	(Serra, et al., 2022), (Heikkilä, et al., 2022)
	Maritime logistics capabilities and service	(Jovi´c, et al., 2022), (Iman, et al., 2022)
	Digital transformation	(Heikkilä, et al., 2022)

	Sustainable port performance	(Heikkilä, et al., 2022)
	Low carbon emission	(Heikkilä, et al., 2022)
Efficient information flow	Port operational efficiency	(Serra, et al., 2022) (Serra, et al., 2022), (Sahu , et al., 2022), (Caldeirinha & Nabais, 2022), (Monzon Baeza & Ortiz, 2022)
	Maritime shipping network	(Serra, et al., 2022)
	Maritime logistics capabilities	(Clott & Hartman, 2022)
	Digital transformation	(Sahu , et al., 2022)
	Terminal operation	(Li, et al., 2022)
Maritime logistics capabilities	Maritime logistics capabilities	(Iman, et al., 2022), (Clott & Hartman, 2022)
Contribution of maritime institution	Maritime logistics capabilities	(Kuo, et al., 2022), (Vitellaro, et al., 2022) , (Clott & Hartman, 2022),
	Maritime shipping network	(Kuo, et al., 2022), (Vitellaro, et al., 2022) , (Clott & Hartman, 2022)
Strategies for digitalization and port Sustainability	Sustainable port performance	(Jugovi'c, et al., 2022), (Belmoukari , et al., 2023), (Othman & El-gazzar, 2022), (Othman & El Gazzar, 2022), (Heikkilä, et al., 2022)
	Low carbon emission	(Jugovi'c, et al., 2022), (Belmoukari , et al., 2023), (Othman & El-gazzar, 2022), (Othman & El Gazzar, 2022), (Heikkilä, et al., 2022)
	Digital transformation	(Jugovi'c, et al., 2022), (Belmoukari , et al., 2023), (Othman & El-gazzar, 2022), (Othman & El Gazzar, 2022), (Sahu , et al., 2022)

	Port operational efficiency	(Belmoukari , et al., 2023), (Othman & El-gazzar, 2022), (Serra, et al., 2022) , (Sahu , et al., 2022)
	Maritime shipping network	(Heikkilä, et al., 2022)
Automation	Maritime shipping network	(Heikkilä, et al., 2022)
	Operational efficiency	(Yang, Meng, & He, 2022), (Hake, et al., 2023)
	Low carbon emission	(Yang, Meng, & He, 2022)
	Maritime logistics capabilities and service	(Yang, Meng, & He, 2022)
	Terminal operation	(Yang, Meng, & He, 2022)
	Digital transformation	(Yang, Meng, & He, 2022)
Monitoring and traceability	Port operational efficiency	(Caldeirinha & Nabais, 2022), (Li, et al., 2022), (Monzon Baeza & Ortiz, 2022), (Zhou, et al., 2022), (Aksentijevi´c, et al., 2022), (Cil, et al., 2022), (Yang, Meng, & He, 2022)
	Terminal operation	(Li, et al., 2022), (Zhou, et al., 2022)
	Maritime logistics capabilities	(Zhou, et al., 2022)
	Digital transformation	(Cil, et al., 2022), (Yang, Meng, & He, 2022)

Source: Developed by Author

FUTURE RESEARCH DIRECTIONS

Considering the data presentation of the research, the researcher could draw attention towards identifying future directions. This new phenomenon in the maritime industry, considering digitalization and port competitiveness, has not been considered by previous and recent researchers. Therefore, for the development of maritime trading and the global supply chain, it is necessary to comply with these new directions through their research. On the other hand, political, economic, technological, environmental, social, and cultural phenomena in the world

have been rapidly changing, and adaptation to these changes is essential for sustainable maritime trading in the country and the global supply chain.

The characteristics and relationship between digitalization and port competitiveness make for a futuristic view of maritime trading operations. Therefore, future directions can be identified as the accumulation result of these research findings. Specially those based on the positive aspects of these characteristics and relationships. Stakeholders in this global supply chain are inventing new technologies as they emerge for the digitalization of port activities. Digitalization consists of many technologies that are used for automated terminal operation, security systems, identification, etc. This direction of innovation needs to be considered as an emerging technology for the future development of the maritime sector.

Likewise researcher has identified futuristic developments in the maritime sector through research findings (Table 6). Such as innovations, enhancing stakeholder networks, balancing port sustainability and commerciality, increasing the involvement of maritime institutions, and real-time information flow.

Innovation: The direct and indirect effects of technology adoption, innovation, and diffusion on value creation and competitive advantages will be a novel contribution to the study of such a relationship. With this technology, key changes have been happening in maritime logistics. Such as innovations in port operation and shipping transportation (Farah et al., 2022; Tsvetkova & Hellström, 2022).

Port efficiency and competitiveness are interconnected terms (Jiang et al., 2022). Bhandari, (2022) has highlighted that emerging new technologies provide strategic opportunities for institutions and organizations to develop their competitiveness in various management fields, including logistics and supply chain management. He has categorized this innovative technology into three categories: automatic identification technology, communication technology, and information technology.

According to the findings of the research, several attempts can be identified as the emerging technologies in the maritime industry. Kuo et al., (2022) has indicated ten digital transformations and those improve port operations while also improving customer relationships and sustainability. Gavalas et al., (2022) has mentioned emerging technologies as (1) sophisticated cloud computing, (2) broadband internet connections, (3) enterprise resource planning, (4) customer relationship management, and (5) an e-commerce website which create

firm-level efficiency. Those promote efficiency across shipping firms and divisions (Gavalas et al., 2022).

Further automation, big data, and artificial intelligence help to economically carry out port operations, and it needs better governance of the port (Lin & Chang, 2022). The growing interest in adapting 5G and virtual reality (VR) technology intensifies industrial operations by improving efficiency and safety. These innovative technologies increase the value of the network and create competitive advantages through enhancing the efficiency of the supply chain (Han et al., 2022). Therefore innovation is creating a version of maritime trading. In addition to that composable technologies is a major innovation in the port industry. It companies to seamlessly integrate and automate their workflows across different platforms. Composable technology means building on the digital core that companies have in place to power their businesses, quickly incorporating required new or enhanced capabilities through additional applications, and allowing for easy integration (McGuigan & McKillips, 2022)

This positive correlation impacts the need to invest in the digital infrastructure by adopting digital technology, empowering talents to get more benefits from the transformation (Kuo et al., 2022). Also, this technology facilitates the sustainable port's management of changing business requirements (Othman & El Gazzar, 2022) and, it will reduce the manpower requirement and improve fuel consumption with efficient service (Farah et al., 2022).

Enhancing Stakeholders' Networks: Relationships among stakeholders (port authorities, ministry, harbormaster's offices, freight forwarders, agents, terminal operators) can be enhanced by adapting technology (Jović et al., 2022). As a result of, Most of the port recognizes the importance of not only investing in infrastructure but also smart technologies and integration within the port community (Othman et al., 2022). Digitalization integrates all the parties into a single port and connected all the ports (Farah et al., 2022). Also, it makes bridges, gives power (Liu et al., 2022), reduces costs, and enhances the maritime supply chain's efficiency (Gavalas et al., 2022; Liu et al., 2022).

As an example, the terminal operating system provides the tracking facilities for the cargo movement while all parties are aware of all the container data in real-time (Othman et al., 2022). This real-time tracking technology improves connectivity, procedures, and function ability throughout the port administration and cargo owners. It reduces cargo delays and increases efficiency between shipping lines and ports (Serra, et al., 2022), (Jović, et al., 2022), (Serra, et al., 2022), (Caldeirinha & Nabais, 2022). Tracking is also important because it

verifies that the correct container is loaded into the correct vessel at the right time. That means actual data can be identified. Also, logistics service providers, freight forwarders, and container warehouses are other information users in this supply chain (Rodeigue & Notteboom, 2021).

Barcodes and global positioning systems give better information about shipping and cargo movement by enhancing supply chain performance, utilization rates, and container cycle volume (Calatayud et al., 2020). Cargo passes various ports and a variety of stakeholders who need information about cargo location, reasons for delay, and arrival time. Because they are not actively participating in container handling (Rodeigue & Notteboom, 2021).

This connectivity will improve the logistics capabilities (international logistics capabilities, green logistics capabilities, and total logistics capabilities) in the port (Jović, et al., 2022) and increase the service through this digitalization (Iman et al., 2022; Zeng et al., 2022). As a result, throughout the network, stakeholders will create concrete new businesses, new services, and introduce new channels to generate additional revenue (Farah et al., 2022). And, achieve the win-win situation.

Therefore, it creates a business opportunity for the stakeholders and the country by improving their customized service in the maritime field for the entire network (Shi et al., 2022). And make the digital transformation enhance sustainability and low carbon emissions as the benefits of this connectivity (Heikkilä et al., 2022). Every node of the chain is being collaborated on through this technology.

Balancing Port Sustainability and Commerciality: Most industries in the world have been facing novel, unpredictable, and extraordinary challenges. As a result, operational decisions made by them are liable, accountable, and reflect sustainable initiatives (Cavalli et al., 2021). Sustainable initiatives are required for the maritime business as an emerging trend in the shipping industry. As a result, port authorities have been influenced to adapt this green governance practice in the port (Jugovic et al., 2022). Also, it is a part of the smart port and needs to consider operations, environment, energy, safety, and security for sustainable performance. This research shows the positive impact on port competitiveness through sustainable port performance, low carbon emissions, digital transformation, operational efficiency, and maritime shipping networks, and it requires strategies for digitalization and port sustainability (Table 6).

For instance, Industry 4.0 and smart applications have been adopted by many companies and

well-advanced ports. And digital innovation makes the difference between automation, sustainable development, and cooperation in the future (Othman & El-gazzar, 2022). Hydrogen energy in Automated Container Terminals (ACT) will become more popular as the low-carbon transmission in the port due to effective usage of clean energy (Yang et al., 2022). Therefore, smart ports, technology, and sustainable performance have been becoming necessities for sustainable port operations (Othman & El Gazzar, 2022).

According to the dictionary, commerciality means commercial quality or character; ability to produce a profit. One important thing is that the company should have a better understanding of the other parties in the network. They should have better knowledge about the issues and problems and, ultimately, should provide advice to achieve their objectives and outcomes.

Heikkilä et al., (2022) mentioned the importance of maritime shipping network and focused on enhance to compete through managing network effectively. It is a deeper understanding of the customer's environment, challenges, market impact, business strategy, their audiences, political and legislative implications, and a whole host of commercial activities. Through the network, it provides first-class service, enhances competitiveness, and ultimately achieves business goals. Therefore, credibility is important for not only retaining customers but also making a huge profit from their demand. Therefore, future ports will become more sustainable, and most of the companies and ports have been balancing commerciality and sustainability through their innovations.

Increasing contribution of maritime institution:

This research has found that some aspects of the study highlight the role of maritime sector institutions. These are internationally, locally, regionally, and government- or non-government-related. These Global institutions, professional organizations, and associations provide support for digital transformation by providing consultation and funding (Clott & Hartman, 2022), and the social network has initiated the promotion of sustainability (Vitellaro et al., 2022). Shipping professional organizations and associations are providing standards, guidelines, and recommendations for the shipping industry, considering the new trend of the digital transformation (Kuo et al., 2022).

Specially, research highlights the need to enhance port competitiveness through maritime logistics capabilities and a maritime shipping network developed by the maritime institution (Kuo et al., 2022; Vitellaro et al., 2022; Clott & Hartman, 2022).

Innovation centers also work to establish the world's "Blue Economy" by delivering programs and providing funding (Clott & Hartman, 2022). Social media also help to promote the CSR

activities of the port industry (Vitellaro et al., 2022). Meanwhile those issues related to CSR and sustainable development initiatives need to be carried out by the stakeholders. Therefore, third-party involvement can promote the usage of digital technologies and maritime capabilities in the countries. And entrust the port's sustainability. For instance, UNCTAD has been implementing trade facilitation programs around the world. Through this intervention, they increase knowledge, raise funds for the project, and guide the achievement of the sustainable development goals.

Real time information flow:

The flow of goods (cargo), information, and finance can be efficiently and effectively transferred within the decision-makers through ICT as a single-port operation. It helps to make decisions for the different decision-makers (Russo & Musolino, 2021). ICT gives a better interface with stakeholders, assisting them to maximize the bottlenecks, plan well, and achieve the expected gains from international trade (Calatayud et al., 2020). Another important thing is that it guarantees information's relevancy, integrity, and consistency through the sharing and storage of information. And it gives a better economic outcome through better decision-making supported by an information system (Knatz et al., 2022). Also, the information system automatically gives safe guide lines for operating ships with the correct position, speed, path, route, and course (Tran, 2022).

This study identifies the impact of financial information flow on operational efficiency, maritime shipping networks, maritime logistics capabilities, digital transformation, and terminal operations. Caldeirinha & Nabais, (2022) have illustrated that the supply chain can enhance transparency and traceability through physical and informational flow. Because there are multiple players in maritime transportation, they interact with different perspectives, creating conflict with each other. Accordingly, they are adapting technology for their port activities. As an example, many terminals are installing sensors in different locations to grab the data and become more intelligent (Li et al., 2022). Meanwhile, the best real-time information performance and a clear visual are given by the digital twin crane monitoring system (Zhou et al., 2022). Therefore, remote control of the software platform in the terminal operation is accurate and effective. Also, integrated container technologies overcome the inefficiency of container identifications (Aksentijević et al., 2022).

Maritime port security is another approach for mitigating threats and vulnerabilities in ports and port facilities (Ibrahim, 2022). Not only for efficiency but also for security purposes, information sharing is very important for the safety and security of the sustainable network

(Serra et al., 2022). For this purpose, monitoring and tracking can ensure the safety and security of the cargo, routes, and places. The Global Positioning System (GPS) and security through the Automatic Identification System (AIS) are sharing real-time data among the parties to ensure safety and security (Monzon Baeza & Ortiz, 2022). Those approaches that allow for automated, consistent, and complete damage detection (Farah et al., 2022). Precise monitoring and control of the system are vital to port logistics management. They can facilitate the establishment of a sustainable network (Cil et al., 2022). It accelerates the value generation fulfilling real time requirements.

CONCLUSION

Port competitiveness is evolving with globalization and digital transformation. These changes have been impacted by the technological applications used by the stakeholders. Currently, ports have become a more sensitive operational node in the global supply chain. It was backed by efficient informational flow, connectivity of the maritime trading, enhancing the logistics capabilities, and strategies relevant to digitalization and sustainability. As a result, port operations have become more sustainable, maximizing their returns through their efficiency. According to the systematic review, characteristics of the digitalization highly influence the port's competitiveness, both directly and indirectly, and those determinants are interdependent. These characteristics take a broader view of the various aspects of digitalization and port competitiveness. In relation to digitalization, researchers could identify main characteristics such as operational efficiency, maritime logistics capabilities, contribution of maritime institutions, strategies for digitalization and port sustainability, stakeholder connectivity, efficient information flow, automation, decarbonization, monitoring and traceability, and security while identifying the characteristics of port competitiveness: terminal operation, digital transformation, operational efficiency, maritime shipping network, maritime logistics capabilities and service, low carbon emissions, and sustainable port performance.

Authorities and users of the port as the main counterparts need attention about the future requirements of maritime trading. More than the value chain, these directions develop the value network through many initiatives. Such as innovative technology, more complex and collaborative connectivity among the stakeholders, recognizing the importance of profit maximization and sustainability, the fastest information flow, and the growing commitment of international institutions. Considering all aspects and the core functioning of the directions, it is most viable and important to balance sustainability and commerciality among the

stakeholders. The boundary line of these directions is interconnecting each direction. Especially currently, port activities are operated through sustainability initiatives, and economic, social, and environmental strategies are based on the organization's internal and external environmental factors: political, economic, environmental, social, technological, and legal. It is the future research area due to the unpredictable and challenging business environment.

The relationship between these two aspects shows a positive correlation through their characteristics. That could help to achieve the main aim of this research, which is to identify the future directions of the research. However, research concludes that all characteristics indicate future directions while indicating this significant relationship between digitalization and port competitiveness. These directions have border view and future research can pay more attention to this direction for the purpose of making better policies and strategic decisions in maritime trading network.

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