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## SPECIFIC CHARACTERISTICS OF SEAPORTS DEVELOPMENT IN THE CONTEXT OF DIGITALIZATION: INTERNATIONAL EXPERIENCE AND CONCLUSIONS

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### ABSTRACT

The article focuses on the study of specific characteristics of seaports development under conditions of digitalization. The article aims to study features of the development of the international seaport under digitalization to implement the best achievements in Ukraine. The main research method was a systemic-structural approach used to examine seaport digitalization as a part of a logistics chain, including horizontal and vertical links between its elements. To achieve an effective digital transformation, we also used the above method. It helped to study how the factors determined during the study of international practices and possible innovations influence the object under study. The practices, which are of interest for Ukraine and other developing countries, were identified based on the international experience in seaports development under digitalization. The main strategic directions for the digital transformations of the above infrastructural objects were suggested. They involve increasing seaport competitiveness and their effectiveness in the framework of the international transport system. The directions are of interest for public authorities of the governmental and regional levels (while establishing the digitalization policy in the area of sea transport) and the port administrations (while making justified strategic decisions for their development).

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### INTRODUCTION

Seaports are objects of infrastructure that exercise ship and cargo handling on different stages of a logistics chain. The fulfillment of their main task – shipping maintenance – demands coordinated work of all the participants of this process. The effectiveness of the port functioning and its competitiveness on the world transport market depend on establishing an efficient management system and modern technical equipment that meet international requirements. Functioning of commercial seaports in a highly competitive

environment, challenges connected with the pandemic of COVID-2019, implementation of quarantine measures require new approaches to the development of these infrastructural objects. The main tendency of the international modern transport market is digitalization and intellectualization that fasten transformational processes, change standard models and approaches to management using information, telecommunication and computer technologies (Zaychenko, 2021).

Inkinen *et al.* (2021) define port digitalization in the framework of digital information adopted, collected,

stored, analyzed, and used in ports and port communities. Attention should be drawn to the fact that in the modern world digitalization is recognized as “a key driver of the increase in gross domestic product” (hereinafter – GDP) and the development of different sectors of the economy (European Commission, 2010; European Commission, 2021), whereas, according to some opinions, a share of the global informational economy (taking into consideration digital skills and digital capital) accounts for 22.5% of the world’s total. The enormous potential of digital transformations for the development of the world economy, that is estimated by additional profits of more than 30 billion dollars until 2025, is singled out by the World Economic Forum (World Economic Forum, 2021). It is worth mentioning that the biggest ports of the world have recently been undergoing digital transformations. As a result, innovative technologies are introduced, all the participants of the global shipments chain are integrated into a single interconnected network, on the basis of a digital platform with the creation of a single digital transport corridor and the use of artificial intelligence. Technological innovations connected with the implementation of digital technologies give new opportunities for seaports since they influence the boost of the effectiveness of their operational activities, service speed, capacity, additional security. That is why, governments of the developed countries pay considerable attention to the stimulation and support of such processes. Nevertheless, as the results of the study of one hundred port administrations and port operators around the world conducted by the World Bank together with the International Ports and Harbors Association shows, only 34% of ports declares readiness to meet the demands of the International Maritime Organization regarding the electronic data exchange ship-to-shore, while more than 31% has not taken any measures in this sphere. In doing so, there were singled out the following obstacles: the absence of necessary funding for the digitalization by financial institutions; an ineffective cooperation between the key interested parties in the ports; gaps in the legislative regulation (International Ports and Harbors Association, 2021).

Due to the above-mentioned factors, in Ukraine as well as in other developing countries, which are the elements of the international transport chains, the level of seaports digital development is significantly below the world average. Accordingly, there is a demand for

justified radical changes of the strategic development of these infrastructural objects on the basis of leading practices. Taking this into consideration, there is an urgent need for the study of the international experience in digitalization of the world leaders in the area of the port industry. Its implementation will encourage the development of the seaports in Ukraine. Therefore, the aim of the article is to study features of the development of the international seaport under digitalization to implement the best achievements in Ukraine.

#### **METHODOLOGY**

This study concentrates on the specific features of seaports development in the context of digitalization. The growth of international sea trade volumes influences the growth of cargo turnover and handling charges in the international seaports. Big seaports located in the developed countries have notable achievements in the area of digitalization that facilitated their effective development, optimization of the main processes and growth of their competitiveness. It has been demonstrated that the biggest volume of containerized sea trade is realized by Asian ports - 64,9 %, while the second place with a serious backlog is occupied by Europe. Therefore, special attention is paid to Asian and European ports that is determined by their importance in the international sea trade and shipping. The practices of seaports digitalization in different parts of the world (under condition of their adaptation) are interesting for infrastructural objects located in the developing countries, which are elements of the international transport chains (including Ukraine). Among the international ports which are characterized by considerable digital transformation it is necessary to mention the following ones: Rotterdam, Qingdao, Singapore, Busan, Xiamen, Shanghai, Antwerpen, etc. Their experience constitutes the ground for generating the strategic directions for the development of Ukrainian seaports on the basis of digitalization in order to increase their competitiveness and effective functioning within the international transport system.

The methodological framework of the research is conceptual issues of modern economic science, theories of public administration, general principles of a scientific research, works by international scientists on digitalization and seaports development. The main method of the research is a systemic-structural approach that allows to study the seaport digitalization process as

an element of the logistics chain, taking into consideration the existing horizontal and vertical connections between the elements, to examine the influence of the range of factors (singled out on the basis of the international practices study) as well as possibilities to introduce innovations on the object under study in order to ensure its effective digital transformation. During the research such approaches and methods were also used: synergistic approach, analysis of monographs, comparative analysis (while investigating special features of the seaports development in the context of digitalization); integrated approach (while generating priority areas for the seaports development in the developing countries); statistical analysis (while analyzing tendencies of the development of the leading international seaports). The legal framework of the research consists of the current legislative and normative documents of the developed countries that regulate digital transformations and the development of the port industry.

The methodology of the research consists of five consecutive stages (Figure 1). Firstly, on the basis of the statistical data the international sea trade volumes as prerequisite for the international seaports development were analyzed. On the second stage, the main tendencies

for the seaports development by the regions of the world were studied, based on a time series analysis. On the third stage, using statistical methods, the ratings of the seaports were compiled, and the port industry leaders were defined. On the fourth stage, innovative technologies and digital solutions applied in big international seaports were examined, their efficiency in the optimization of logistical processes was defined. The technological transformations of production processes, changes in the management paradigm and formation of a corporate culture and external communication that accompany digitalization processes were determined. The difficulties faced by the leading ports during these digital transformations were studied. The main obstacles, which can impede the automation in the Ukrainian ports, were analyzed. On the fifth stage, the priority directions for seaports development at an early stage of digitalization were identified, which under condition of their adaptation can be implemented in Ukraine and other developing countries. The data of this study constitute legislative and normative acts, researches conducted by the International Ports and Harbors Association, the World Shipping Council, UNCTAD, and the World Bank, the world seaports databases, works by international scientists.

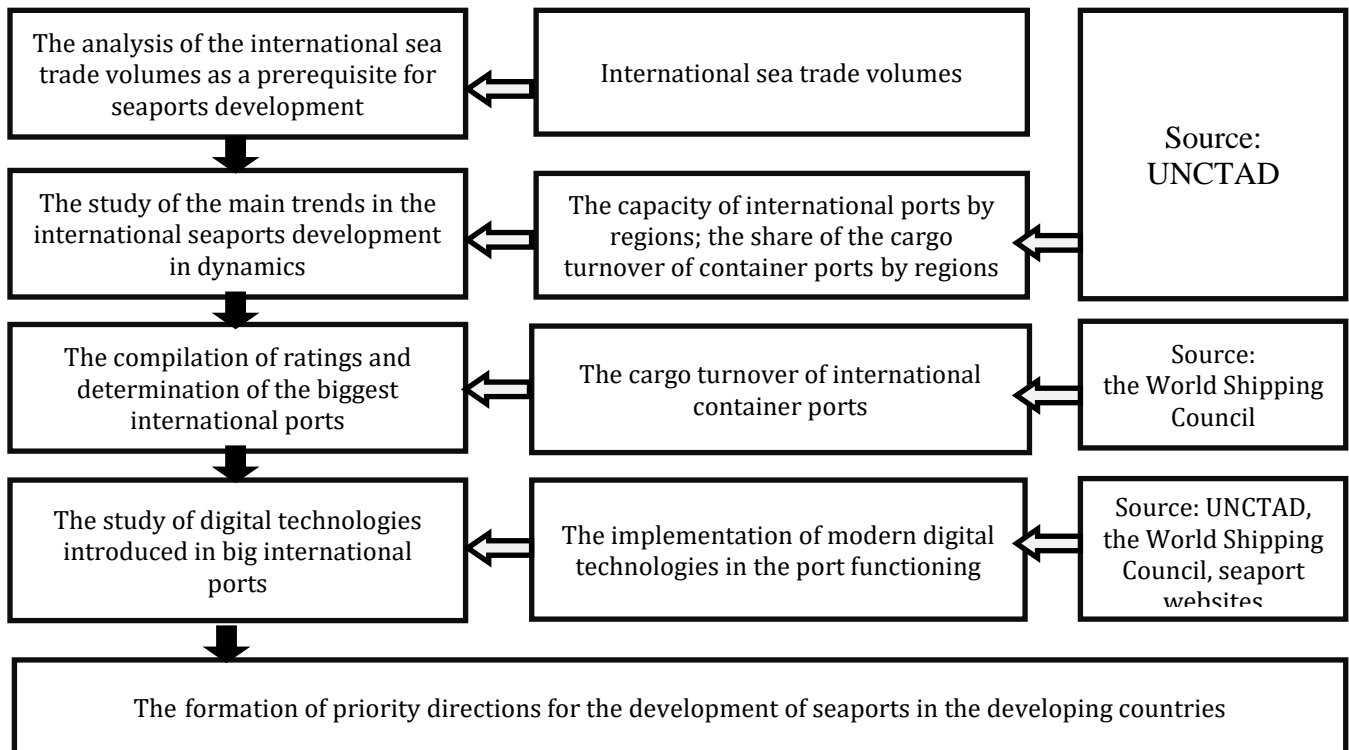


Figure 1. The main stages forming the research methodology

Source: developed by the authors

**RESULTS**

**The study of the international trends in seaports development**

In the last 10 years the international sea trade volumes have increased by 31,7 % and have reached more than 11 billion of tons in 2019 (Figure 2) that influence the

growth of cargo turnover and handling charges in the international ports. While highlighting the importance of container transport and the role of containers in the multimodal transport, it is necessary to note that in 2019 the total cargo turnover of the international seaports has increased up to 811.1 million TEU (by 2 % in comparison with 2018) (Table 1).

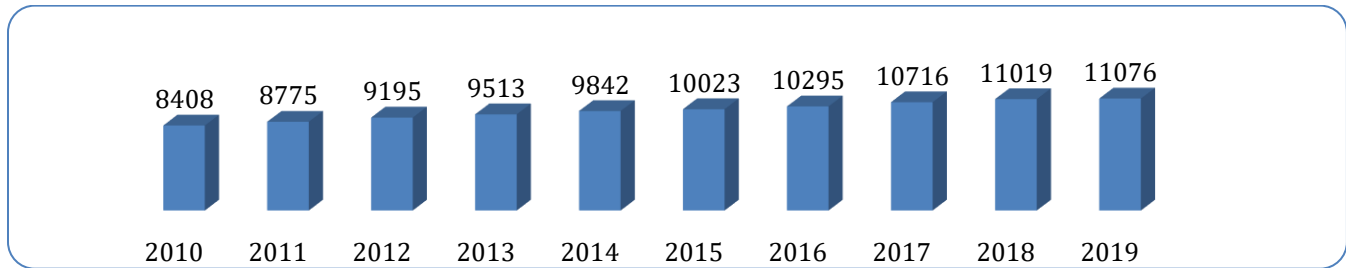


Figure 2. International sea trade volumes, millions of tons.

Source: developed by the authors according to the data (UNCTAD, 2020).

Table 1. The capacity of container ports of the world by regions. million. TEU\*.

Regions of the world	2018	2019	Growth rate. %
Asia	514.9	526.7	2.3
Europe	121.7	123.6	1.5
North America	61.6	62.5	1.6
Latin America and the Caribbean region	52.3	52.6	0.7
Africa	31.3	32.5	3.9
Oceania	13.5	13.2	-2.2
Total	795.3	811.1	2.0

Source: developed by the authors according to the data (UNCTAD, 2020).

It is also necessary to mention that more than a half of the container ports of the world is concentrated in Asia that plays a notable role in the international sea trade and shipping (Figure 3). The biggest volume of the containerized sea transport corresponds to the port traffic in Asian countries – 64.9 %, while the second place with a serious backlog is occupied by Europe

(15.3%), the third place is divided with equal results between the countries of North America and the countries of Latin America and the Caribbean region (7.7%).

At the same time, the tendency for the increase of ports capacity is characteristic of all the regions of the world, apart from Oceania.

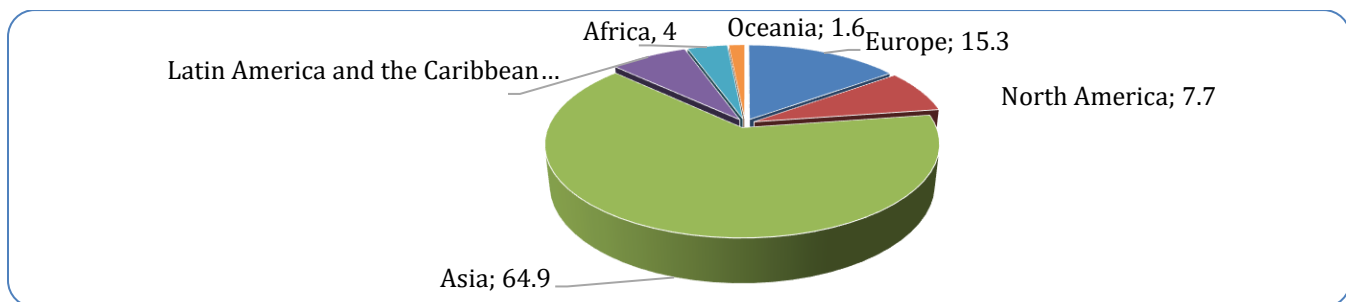


Figure 3. The distribution of the cargo turnover of the containerized international ports by the regions (2019), %.

Source: developed according to the data (UNCTAD, 2020)

It is important to pay attention to the fact that out of ten biggest international ports, nine ports are situated in Asia, including seven ports in China (Table 2). According to the results of 2019, Shanghai topped the ratings of the biggest international ports, with its cargo turnover having increased by 3.1% and reached 43.3 million TEU.

The second place is occupied by Singapore (with the cargo turnover of 37.2 million TEU), an important hub of container transportation from one liner service to another with a view to deliver them to their destination. Shenzhen was on the fourth place for a long period, but it was replaced by Ningbo-Zhoushan.

Table 2. The top-10 list of the containerized international ports (according to the data of 2019)

No.	Port	Cargo turnover, millions TEU						Growth rate, %
		2014	2015	2016	2017	2018	2019	
1	Shanghai, PRC	35.3	36.5	37.1	40.2	42.0	43.3	3.1
2	Singapore	33.9	30.9	30.9	33.7	36.6	37.2	1.6
3	Ningbo-Zhoushan, PRC	19.4	20.6	21.6	24.6	26.4	27.5	4.2
4	Shenzhen, PRC	24.0	24.2	24.0	25.2	25.7	25.8	0.4
5	Guangzhou Harbor, PRC	16.2	17.2	18.9	20.4	21.9	23.2	5.9
6	Busan, the Republic of Korea	18.6	19.4	19.8	20.5	21.7	22.0	1.6
7	Hong Kong, PRC	22.2	20.1	19.8	20.8	19.6	21.0	7.1
8	Qingdao, PRC	16.6	17.5	18.0	18.3	19.3	18.3	-5.2
9	Tianjin, PRC	14.0	14.1	14.5	15.1	16.0	17.3	8.1
10	Jebel Ali (Dubai), UAE	15.2	15.6	15.7	15.4	14.9	14.8	-0.7
Total		215.4	216.1	220.3	234.2	244.1	250.4	2.6

Source: calculated by the authors according to the data (World Shipping Council, 2020).

According to the World Shipping Council, in 2019, the total cargo turnover of the ten biggest international ports increased up to 250.4 million TEU, that is 2.6% more than in 2018. However, it is necessary to observe the slowdown in cargo turnover (from 4.2 % in 2018 to 2.6 % in 2019), which is determined by the following factors: the economic slowdown of many countries; the decrease in sea trade volumes; the decline of the demand in the oil market, etc.

### The study of the international experience in seaports development in the context of digitalization

In the last decades, influenced by the global digital transformations, the concept of the biggest seaports development has been notably changed. Their experience in active digitalization, which involves the introduction of modern informational technologies to all the processes, must become the ground for other seaports, which are the participants of the logistics chains in the global transport system, to generate development priorities. This is a burning issue in conditions of modern challenges. It is necessary to note that this approach involves not only the use of the

innovative software or modern equipment, but also fundamental changes in a port managing paradigm, formation of a corporative culture and external communication. It is observed that the introduction of these processes is linked to the use of unmanned container handling machines in the Port of Rotterdam in 1993. Nowadays such innovations as robotics, automation, artificial intelligence, unmanned means of transport and equipment, Blockchain technology, etc. play an important role in the international seaports development.

However, it is worth pointing out that generally this process is under implementation, because 97% of container terminals in the world is not automated (the share of completely automated container terminals is 1%, while the semi-automated ones correspond to 2%). Thus, completely automated international container terminals are the following: Victoria International Container Terminal (the Port of Melbourne, Australia), international container terminals in the Port of Sydney (Australia), Qingdao Qianwan Container Terminal (the Port of Qingdao), the HHLA Container Terminal Altenwerder (Hamburg, Germany), etc. Semi-automated

container terminals are DP World Australia's Brisbane terminal on Fisherman Islands (Australia), Container Terminal Burchardkai (Hamburg, Germany), Container Terminals Pasir Panjang 1- 4 (the Port of Singapore), the Oi 5 Container Terminal (Tokyo, Japan), etc.

Among the main problems that slowdown the automation processes in the ports scientists single out high costs; the lack of qualified staff or sources for automation implementation and its management; the trade unions concern about job cuts; considerable time required to implement the automation (Drewry Maritime Research, 2019). Therefore, the experience of the leaders in digitalization must become a benchmark to avoid obstacles in the process of digital decisions implementation, to generate priorities for the seaports development in Ukraine and in other countries at the initial stage of digitalization, which is especially relevant during the global financial crisis.

In this context, attention should be paid to the practices implemented in the Port of Rotterdam that is considered one of the leading European ports. It underwent a large-scale digital transformation under the theme 'the smart port of the world'. The project involves creating a digital twin along all the port zone, based on the Internet of

things, with a digital copy of the port operations which will allow to receive autonomous connected cargo ships till 2025 because of the ship tracking as well as infrastructure and related data management.

However, the large-scale transformations realization in the Port of Rotterdam was proceeded by the thorough preparatory work, for instance, the Project 'Hyper smart' Container 42. It was launched in 2019 and involved shipping the experimental container that was equipped with various sensors, communication equipment as well as solar panels. This container would collect information necessary for creating the port twin (the shipping conditions aboard, by rails and trucking: vibrations, the level of air pollution, temperature, humidity, etc.). Highlighting the massive character and complexity of the Project Container 42, the great number of the participants should be taken into consideration. IBM, Cisco, Esri, Axians, Intel, HyET Solar, Van Donge & de Roo, Awake.ai, Betta Batteries, Simwave, Advanced Mobility Services, Kalmar i Shipping Technology are the main ones. It is worth mentioning that other countries also have experience in digitalization, which is of interest for Ukrainian and other countries' seaports. The summary of these practices is presented in Table 3.

Table 3. The implementation of digital solutions in some international seaports.

Port	Digital technologies	Possibilities
Rotterdam	The introduction of the internet of things, blockchain, technologies of the augmented intelligence and intelligent data	The identification of the optimal route and timing of ship arrival; estimation of the wharf accessibility; improvement of communication between ships and onshore support facilities to manage the traffic efficiently
	Rotterdam Additive Manufacturing LAB was created, which is considered the world's first field laboratory of 3D printing	It provides a wide range of certified metal spare parts for ships.
	Real-time navigation system	It allows to obtain real-time information on the traffic in the port, overburdened infrastructure, etc.
Hamburg	'A smart railway points' system	The installation of sensors helps to analyze the most charged areas of the port railway and avoid a possible standstill
Antwerpen	Testing and further implementation of the blockchain technology	The optimization of the port logistics and minimization of the possibility to manipulate the databases
	NxtPort Platform	The improvement of the data exchange between the interested parties in the port; transparency and intellectual processing of

		information based on combining information, compatibility of the existing systems that will allow to synchronize logistical operations in the port, to reduce the cost and delays, and to boost the port capacity and effectiveness
Tilbury	A mobile application for means of transport booking, specially developed for the terminal carrier, was integrated	The possibility for the carriers to perform orders and inspect the conditions of containers online, with smartphones
Montreal	Web-application Trucking Portal, developed with the aim of	The optimization of the truck's routes, reduction of delays on entering and leaving the terminals
Qingdao	A completely automated container terminal that is controlled with laser scanners and systems of containers positioning in order to fix them exactly and move them to trucks without a driver. The automated equipment planning, automated docking of ships, automated container delivery, and unmanned intellectual gate system were implemented	Completely automated management of logistical processes
Long Beach	A completely automated terminal. It has a mega crane with an enormous carrying capacity and ability to handle several containers simultaneously, providing ship supply services	Completely automated management of logistical processes
Singapore	Testing and implementing of the blockchain in the limits of the supply chain	The optimization of the port logistics and minimization of the possibility to manipulate the databases
Busan	The implementation of blockchain in the limits of the supply chain	The optimization of the port logistics and minimization of the possibility to manipulate the databases
Xiamen	Xiamen Ocean Gate Container Terminal – the first smart port in China, where the complete automation of the intellectual system of the management of all the operations – from the cargo unloading up to its storage – using 5G technology – was realized.	Completely automated management of logistical processes

Source: generalized by the authors on the basis of (Drewry Maritime Research, 2019; UNCTAD, 2020; World Shipping Council, 2020).

Studying the international digitalization practices, we consider it relevant to pay attention to the Blockchain technology, whose effectiveness is being discussed and investigated (WEF, 2021). As a result of the Fourth Industrial Revolution, this technology permits a real-time tracking and management of logistical activities in the supply chains, ensuring a secure data interchange between the parties.

Testing and further implementation of the Blockchain logistics technology in the Port of Rotterdam is of

practical interest for the seaports that are participants of the global logistical chains. It will enhance the development of sea transportation as well as the optimization of the sea and port logistics. The uniqueness of the project consists of covering all the supply chain. Its realization is supported by more than fifteen state and private companies, located in the Netherlands, and by Ministry of Economic Affairs. It is also important to note that there is a blockchain

laboratory functioning in the Port that undertakes scientific and research activities and data processing.

It should be mentioned that testing of this technology and pilot projects were introduced in other seaports around the world, which permitted to change a traditional organization of logistical processes and document flow. The main ones are Antwerpen, Singapore, Qingdao, Busan, etc. The experiment carried out by the Commonwealth Bank of Australia, Wells Fargo and Brighann Cotton deserves attention. In the course of this experiment the efficiency of the Blockchain technology integration and smart contracts was proved, according to the results of the intercontinental sea transporting from the USA to China (the Port of Qingdao).

Regarding the pilot projects on the Blockchain technology implementation, it is worth drawing attention to the possibility to ensure a sufficient level of security of logistical processes. In this context, the testing of the security system TVBx3, founded on the Blockchain architecture should be pointed out. This security system is based on 44-bit alphanumeric cryptographic coding (in contrast to 6-figure numeric cryptography, which is in use nowadays). The system can verify the absence of the goods substitution along the whole supply chain and presupposes a new level of the global supply chains security and the international security standards. The testing was conducted by DP World, DB Schenker, Hamburg Sud and the Australian company specialized on wine production (IUS) in the intermodal supply chain from South Australia to the Port of Qingdao (China), using road and maritime transport (the chain length is 8,1 thousand kilometers).

Summing up all above mentioned, it is important to note that the pilot projects and testing proved the efficacy of the Blockchain technology for the logistic network organization in seaports. It is determined by the following benefits: the possibility for all the participants of the process (suppliers, shippers, port operators, and the customs) to obtain real-time information about the delivery using the effective blockchain-platform; the boost of information processing and updating rates; high accuracy of contracts and processes implementation as the result of their automation; information transparency for the participants of the logistic process (in case they have an access key); a high security level through the use of information coding, which prevents unauthorized

interference in the functioning of the system; logistical costs optimization.

However, it must be highlighted that the implementation of such technologies in seaports is linked to a range of problems that can slowdown or impede the realization of these projects. There can be defined the following difficulties: specific and unique contract particulars between the participants of the logistic process that complicate the universalization and requires this option to be set in the system; the difficulty to introduce this system by small companies because of the lack of technological capacity and funding.

Emphasizing the blockchain importance for seaports development, it is necessary to agree with the scientists who state that this technology will be a catalyst for a greater consolidation in the area or will encourage the creation of a two-level system where some lines will function with the digital technologies only sporadically. Taking all above mentioned into consideration, various online platforms for the logistics services, which were introduced by the companies serving for seaport terminals in the developed countries (Denmark, Switzerland, France, Germany, etc.), are of practical interest. Among them it is possible to single out the following platforms:

- platform "Trade Lens" (the company "Maersk", Denmark; "Mediterranean Shipping Company", Switzerland; "CMA CGM Group", France; "Zim", Israel) – due to the integration of all the supply chain participants, it allows to obtain real-time information about cargo movements that facilitates the cost cuts in the document flow; it is characterized by high security and confidentiality levels;

- platform "Quick Quotes" ("Hapag-Lloyd", Germany) – is an online service of calculation of the rates. It helps to calculate the container transport cost, book freight, paperwork, cargo tracking immediately;

- "Freightos" ("CMA CGM Group", France) – is the global online platform that is used in the area of the international cargo transportation and gives an access to information on rates, routes, schedules, providing equal opportunities for big and small cargo shippers;

- "KN Pledge" ("Kuhne+Nagel", Switzerland) – is an online service of shipment booking with a performance guarantee and a possibility to expand cargo insurance;

- "SeaRates" ("Dubai Port World", UAE) – is an interaction service with the online market, which



permits for cargo shippers to compare the rate of all the available delivery options and to indicate the delivery time. It combines the data of different shipping lines and maritime agencies, displays real-time movements of the cargo and records the time spent in transshipment ports;

- Joint project of “Alibaba Group” and “Ant Financial Group” (“China Merchant Port Group”, China) – is the technology of intellectual ports based on the newly invented Blockchain technology that integrates customers, sellers, logistics companies, banks, the customs in order to perform contactless digital operations of export and import in the seaports. It provides a possibility to control the port infrastructure remotely (cranes, equipment, etc.).

The experts (Knickrehm et al., 2016, Montwiłł, 2014) put forward that the use of digital platforms is able to reduce the transit time in the sector of the international trade by 40%, and to decrease the cargo transfer costs by 15%. It is necessary to underline that Port Community

Systems (PCS) is regarded as the key tool of the seaport digitalization processes realization, which is an effective real-time information system. This fact was repeatedly highlighted in the reports of the World Bank (World Bank, 2020). PCS allows to optimize logistic processes in the supply chains by establishing the data exchange standards; to reach the data transparency at all stages of the cargo handling; to increase the port processes effectiveness and their speed, in particular, by simplifying the document flow system; to ensure a high level of cybersecurity of all the logistics chain in the port through Cyber Threat Emergency Response Centre. The Port of Los Angeles, whose port community system is acknowledged to be the best in the world, is the best example of the international practices in this area. Built within the Cyber Threat Emergency Response Centre system, it was the first port of the world that was certified to the information security management standard ISO 27001. The benefits of PCS implementation are presented in Table 4.

Table 4. Benefits of Introducing Port Community Systems.

Port community system benefits at the Port of Los Angeles	Port of Barcelona: Gate exit	Port of Shanghai e-logistics community system benefits
Cargo visibility: Increase from 2 to 14 days prior to vessel arrival;	Document checks while exiting container terminals at the Port of Barcelona took at least 3 minutes per truck. Trucks were required to stop and have documents checked to ensure the container was cleared to leave the terminal, including customs clearance	Port of Shanghai e-logistics system evolved from a container terminal operation system (TOPS-C V1.0, 2010) to a fully functioning PCS serving government agencies (such as customs, inspection, and maritime bureaus), shippers, and logistics service providers, including hinterland terminals (TOPS 5.0, 2015)
Productivity: 8–12% projected productivity increase as solution is scaled across the Port of Los Angeles;	Benefits: In 2019 the Port of Barcelona partnered with Portic to implement the new PCS-enabled electronic procedures, creating an automatic customs control of departures. Portic has saved transport companies more than 50,000 hours of waiting time at terminal exit	Benefits: 75% of document exchanges are electronic; 80% load rate of domestic heavy container trucking; 12% efficiency improvements of tire gantry crane operation; 4,000-ton reduction of annual diesel consumption; US\$60 million annual savings of operating cost
Ease of use: 93% of pilot participants agree that the data in the portal are easy to understand and valuable		

Source: summarized according to the data (Port of Los Angeles, 2020; Port of Barcelona, 2020).

As the results of the researches demonstrate, the developed countries pay serious attention to seaports development and their digitalization. Thus, the state policy is based on a strategic approach that involves creating corresponding strategies specified by the action

plans on the national level. In order to increase the effectiveness of the transport industry digitalization, the use of innovative means of funding and state-private partnership is planned. It is worth mentioning that such practices are characteristic of the countries of the

European Union, the USA, China, etc. that provides a complex vision of the problem and its solution on the national level.

### **The formation the seaports development priority directions in the developing countries**

The study of seaport development tendencies in the context of digitalization allowed to state that it is necessary to create the relevant policy in the developing countries, which are the elements of the international transport system. It must be noted that such policy, built on the best international experience, should be complex and directed to the support of digital transformations in this area. So, among the main priorities in Ukraine there should be distinguished the following:

- the formation of the legal basis in the area of sea transport digitalization and its harmonization with the international norms considers national conditions and prospects for the seaport development, which will help increase partnership and integration of the Ukrainian transport system into European and global transport networks;

- the cooperation enhancement with the European Union countries in the area of Ukrainian integration into the European digital market; the participation in specialized projects in the sphere of transport network technological and digital modernization; the involvement of Ukrainian IT companies in such projects;

- the promotion of innovative activities in the area of digital development; the support of projects aimed at using modern information technologies (relevant software, satellite connection, and navigation systems), which will permit to create an efficient real-time communication system between the participants of logistic processes, to increase the level of technological processes automation, and to optimize operations;

- the development and approval of strategic documents that set the directions, tools, and mechanisms for the state seaports digitalization policy realization; the formation of a set of programmes in the sphere of infrastructure development, software, construction of a successful partnership in the information exchange in the area of cybersecurity;

- the development of the industry domestic market, the use of high technologies in the transport sphere; the development and the use of software; the stimulation and support of the innovative development

of infrastructural objects aboard; the development of modern information-communication infrastructure;

- the use the Internet of things, introducing a relevant route optimization and traffic management software;

- the development of the Blockchain technology that will permit to track cargo movements and provide customers awareness along the whole supply chain;

- the creation of a modern communication system, centres of data storage and processing in the seaports, using up-to-date software including the models of public-private sector partnerships; the formation of an appropriate legal framework for these processes realization;

- the promotion of investing activities and accumulation of resources for the financial support of digital transformations; the introduction of innovative financial products; the involvement of private sector investments;

- the prevention, elimination and management of associated risks in cyberspace, the implementation of new cybersecurity technologies; the creation of relevant sector-specific standards in the sphere of cybersecurity;

- the development of a modern scientific basis and the improvement of a staff training system for the transport industry, taking into account the contemporary digital competences; the support of scientific researches regarding digital innovation and cybersecurity at the governmental level, the promotion of collaboration between the seaports, universities, scientific-research institutions in the area of scientific researches and networking.

### **DISCUSSION**

It is worth mentioning that the ideas of the digital economy, which became a foundation of the Fourth Industrial Revolution, are connected with Daniel Bell's theory of the information society and the works of M. Castells (1985; 1987; 1989). The main theoretical principles of digitalization and special characteristics of the economic development in the context of digital transformation were explored by Mesenbourg (2001), Negropte (1995), Tapscott, (2009), etc. The contemporary notion of Industry 4.0 within the Fourth Industrial Revolution was put forward by Klaus Schwab (2015).

It is necessary to highlight that the problems of the international transport network development are a

subject-matter of discourses in the majority of the countries, which influences the creation of the related governmental policy. Alderton (2008), Chen (2016), de Langen (2010); Manginas *et al.* (2017), Notteboom (2017), Sugawara (2017), and Verhoeven (2016) among others underline the importance of digital transformations, particularly in the seaports of different countries, the variety of tools and approaches (robotics, artificial intelligence, etc.), and the necessity of corresponding strategical tasks creation.

It should be said that the digitalization processes, including seaports, are one the global priority problems that is being studied by international organizations. Thus, the most important priorities for the seaport industry digital transformation in countries at different stages of development are scrutinized in the documents of the European Commission (2021), the World Bank (2020), the World Economic Forum (2021). The level of readiness of the seaports for the supply chain digitalization is studied by the International Ports and Harbors Association together with the World Bank (2021), which allowed to define the main problems and obstacles related to the collaboration between the interested parties, and to formulate relevant recommendations on their removal. Studying different seaport development models, the United Nations Conference on Trade and Development (UNCTAD) emphasizes the model Workport that involves 'the maximal computer optimization of all the processes' and recognizes 'the seaport management policy on the basis of priority attention to urgent and crucial issues' (UNCTAD, 2020).

It is worth pointing out that the digitalization processes, including those in the seaports, are kept under review by the transnational corporations, which publish their own researches on this subject-matter, considering it as an impetus for the economic development. There are McKinsey Global Institute (Manyika *et al.*, 2015), Global Institute, The Boston Consulting Group (Alm *et al.*, 2016), Cisco, PwC & SAP (The New Digital Economy, 2018) among them.

However, taking into account the dynamic development of contemporary economic processes, the requirements to the development of the international transport system and its infrastructural objects, which change under the influence of the digital revolution achievements as a tool for the transition to the Industry 4.0, the study of the seaport development in the context of digitalization and

the summary of the best international practices in this area require further researches of this problem at different angles, that differs this study from the existing ones.

## CONCLUSION

In the context of digital transformation of the world economy the adjusting of the concept of seaports development is being actualized. Several infrastructural objects, that are situated in the developed countries, already have various successful achievements in the sphere of digitalization. These practices are of particular interest for the seaports in the developing countries that are the elements of the international transport chains (including Ukraine). Summing up this experience allowed to determine the development priorities that can increase the competitiveness of these infrastructural objects.

It includes formation of the legal framework in the area of digitalization of sea transport and its harmonization with the international norms; the revitalization of cooperation with the countries of the European Union; the stimulation of innovative activities in the area of digital development; the development and approval of strategic documents that set the direction, tools, and mechanisms for the state seaports digitalization policy realization; the development of modern informational-communicational infrastructure; the use of the Internet of things and the Blockchain technology; creation of the modern communication system, centres of data storage and processing in the seaports, using up-to-date software including the models of public - private sector partnerships; enabling the promotion of investing activities and accumulation of resources for the financial support of digitalization; the management of associated risks in cyberspace, the implementation of new cybersecurity technologies; the creation of corresponding sector-specific standards in the sphere of cybersecurity; the development of a modern scientific basis and the improvement of a staff training system for the transport industry, taking into account contemporary digital competences, etc.

However, their practical realization requires the development and implementation of corresponding realization mechanisms including exact funding sources, that presents prospects for a further research. This study can be of interest for public authorities of the state and regional levels (while establishing and realizing the

digitalization policy in the area of sea transport) as well as for port administrations (while making justified strategic decisions for the development of these infrastructural objects).

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