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Article

Using the SWOT Methodology to Know the Scope of the Digitalization of the Spanish Ports

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Abstract: In the specific case of maritime transport, one of the most notable examples of digitalization is smart ports. Their positive impact on the supply chain is enabling processes to be optimized through smarter production. In the case of Spain, the Spanish public entity Puertos del Estado (Puertos del Estado is a public business entity dependent on the Spanish Ministry of Transport, Mobility and the Urban Agenda, with overall responsibility for the entire state-owned port system.) has launched Ports 4.0, the largest open innovation fund for the logistics-port ecosystem. It is therefore necessary to know the point of digitalization in which the Spanish ports are and the present scenario in which they develop their activity. For this purpose, a SWOT analysis (Strengths-Weaknesses-Opportunities-Threats analysis) is proposed, which is an ideal tool to make a reliable diagnosis of the port system in relation to a certain project before which we wish to make a strategic decision, in this case digitalization, in order to establish a concrete action plan in this regard. This should be the first step towards developing the Ports 4.0 project. The main conclusion of the analysis is that Spanish ports are currently at a medium high level of digitalization, and that they continue to update and innovate in order to be increasingly competitive in this market, despite the fact that there is still a long way to go in digitalization. The main challenge for Spanish ports is that technology alone is not useful enough to reach Ports 4.0 status; the technology also needs to be used in an integrated, open and joint way by all the agents of the port community, which is one of the main handicaps at present.

Keywords: digitalization; intermodality; Spanish port system; strategic analysis; Delphi panel; SWOT matrix

1. Introduction

Digital transformation is of utmost importance in the business world with major impacts on any of its sectors. Ports and logistics within the maritime transport are considered here to exemplify those developments. In other words, as actors in global supply chains, seaports are particularly affected by technological change.

Due to the high requirements in the logistics sector, e.g., regarding costs, efficiency, security and sustainability, digital innovation is essential to maintain competitiveness [1].

Since the beginning of containerization in the 1960s, the adoption of information technology and information systems has evolved to become an indispensable success factor for the competitiveness of ports, facilitating communication and decision-making for enhancing the visibility, productivity, efficiency and safety of port procedures that are affected by various conditions [2]. In addition, better integration of government bodies to standardize and harmonize reporting formalities is becoming increasingly important.

Digitalization is pushing the maritime industry beyond its traditional limits and provides many new opportunities to improve the productivity, efficiency and sustainability of logistics [3]. The concept of smart ports, for instance, aims to adopt modern information technologies to enable better planning and management within and between ports. The most urgent needs of digitalization are investments in technology and partnerships for promoting information exchange and better coordination and collaboration, often seen as an obstacle in highly competitive environments. In addition to many new opportunities, important economic problems and problems arise.

Notably, the role of ports has changed drastically from its traditional function, connecting sea and land through loading and unloading operations, to being an essential part of global logistics networks that manage the flow of cargo and provide value-added logistics services in an efficient and effective manner. These ports also need to operate in a safe and environmentally friendly mode.

Owing to its important role in achieving a competitive advantage, a plethora of information systems and technologies have been adopted in port operations in recent decades, allowing more and more electronic transactions to take place [4]. While previous developments have led to a high degree of digitalization and automation, especially in container terminals, there is still considerable potential for improvement.

Therefore, the current phase of the digital transformation is strongly focused on adopting new digital technologies to better measure, monitor and control port operations, e.g., using real-time operational data to predict future events [5]. This may involve advanced pre-processing and data analysis to extract information and knowledge, which can be used in advanced planning and decision support systems. However, the success of the digital transformation lies not only on the use of advanced technologies and methods, but especially in the adaptation of organizational aspects, according to the idea that ‘digital technology is a means, not an end’.

The ports evolve in through their digitalization from the electronic port stage to the Port 4.0 stage and go through the following phases [6]:

- The Port connected phase. This is the state in which port operations have reached a high level of automation, replacing human intervention. The fundamental technology is sensorization.
- The Smart Port phase. It is established around a digital platform that captures information from sensors and IoT networks, processes it, displays it visually, helps make decisions and even acts; all of these actions occur in real time. We are basically talking about Big Data and Machine Learning.
- The Port 4.0 phase. This is a concept analogous to that of Industry 4.0, and includes the flow of information with the outside. Through this process, the intelligence of the Smart Port is added here to the port’s functionality and role as a node in the supply, energy and information networks.

In the Spanish case, the Ports 4.0 capital fund is a corporate open innovation model adopted by state ports and port authorities. The aim is to attract, support and facilitate the application of talent and entrepreneurship to the public and private logistics-port sector in the context of the 4th industrial revolution. The main objective of the Fund is to promote and actively incorporate disruptive or incremental innovation as an element of competitiveness, efficiency, sustainability, safety and security in the logistics-port sector to facilitate its transition to the Economy 4.0.

With the development of this article, the aim is to know, with respect to digitalization, the real current situation for Spanish ports. Based on this knowledge, it is possible to plan a strategy for the future, propose the actions that should be implemented to take advantage of the opportunities detected and prepare protection against various threats. All this can occur while taking into account any weaknesses and strengths. For this reason, a SWOT analysis (Strengths-Weaknesses-Opportunities-Threats analysis) was developed to help find out the status of a project at a given time. In the case study, the project is the digitalization of the Spanish ports nowadays.

2. State of the Art

In terms of today's world, we are talking about Smart 4.0, digitalization, innovation and mainly Economy 4.0. With the resources available, it is possible to change the functioning of the entire global system, especially the transport systems. The digital transformation process of Spanish ports is now unstoppable. Technologies such as the Internet of Things, 5G, blockchain, Big Data or Artificial Intelligence are beginning to be common terms in the vocabulary of those responsible for port facilities. In addition to this, the digitalization of important functions and processes has been added, to the point that the concept of intelligent ports is already being discussed. This is inevitable, on the one hand, because technological progress cannot be stopped; on the other, because the world requires it. The time has come to make (and apply) more sustainable choices that are more oriented toward future life rather than immediate gains. Within these trends, innovation plays a fundamental role, it must be a controlled process, which implies a cultural change, where it is necessary to recreate the flows and processes to generate open innovation. Innovation must be formalized and incorporated into the culture of each company; the ports as industry-enterprises are no strangers to this process. The management of the R&D model associated with innovation must be systematized, verifiable, audited and measured in the port environment. In order to guarantee the control of innovative activities, it is necessary to develop control tools. There is still a long way to go in the port sector to control the management of the change from initiatives to projects. The concept of Port 4.0 is linked to the concept of Industry 4.0, which is associated with the phenomenon of a fourth industrial revolution that implies a change in industrial development capable of generating important social changes in the coming years. It is an industrial concept that makes intensive use of the Internet and the most advanced technology to develop more intelligent and environmentally friendly industrial installations and processes. They involve production chains that communicate rigorously with each other and with markets.

'Puertos del Estado' is the Spanish public business entity that depends on the Ministry of Transport, Mobility and Urban Agenda of Spain. It has overall responsibility for the entire state-owned port system. It is also in charge of executing the National Government's port policy and coordinating and controlling the efficiency of the port system, which is made up of 28 port authorities that manage the 46 ports of general interest. Puertos del Estado has generated a plan called 'Plan Puertos 4.0' through which a fund is provided to promote innovation in the port sector. The 'Fondo Puertos 4.0' is a new inter-portuary compensation fund aimed at promoting and actively incorporating disruptive innovation as a competitive element in the Spanish public and private port logistics sector. The main objective of the plan is 'to promote and incorporate disruptive or incremental innovation as an element of competitiveness in the public and private logistics-port sector', as well as efficiency, sustainability, safety, etc.

The strategies to achieve these objectives are based on complementing internal with external innovation at the level of the port system and port community, entering innovative national and international ecosystems, having a corporate startup incubator for the logistics-port sector and accessing financing and facilitating the capture of private investment for port innovation.

In short, the objective of the plan is to promote entrepreneurship to foster innovation, articulating and linking an external innovation ecosystem that is at the service of the logistics-port sector.

The aim is to consolidate a network of emerging companies and new business lines that develop innovative products for the logistics-port sector, as well as the practical application of new innovation strategies, promoting the adaptation and transition from the logistics-port sector to an Industry 4.0 state.

Currently, we are immersed in the fourth industrial revolution or Industry 4.0 phase. This technology requires a current shift from electronic ports to interconnected ports, which will produce changes in port governance models, not because of a preference for ports to be more public or more private, but because the way of competing and being efficient will be different and it is necessary to adapt management as a result. All these transformation processes basically need 6 factors for their success (Figure 1):

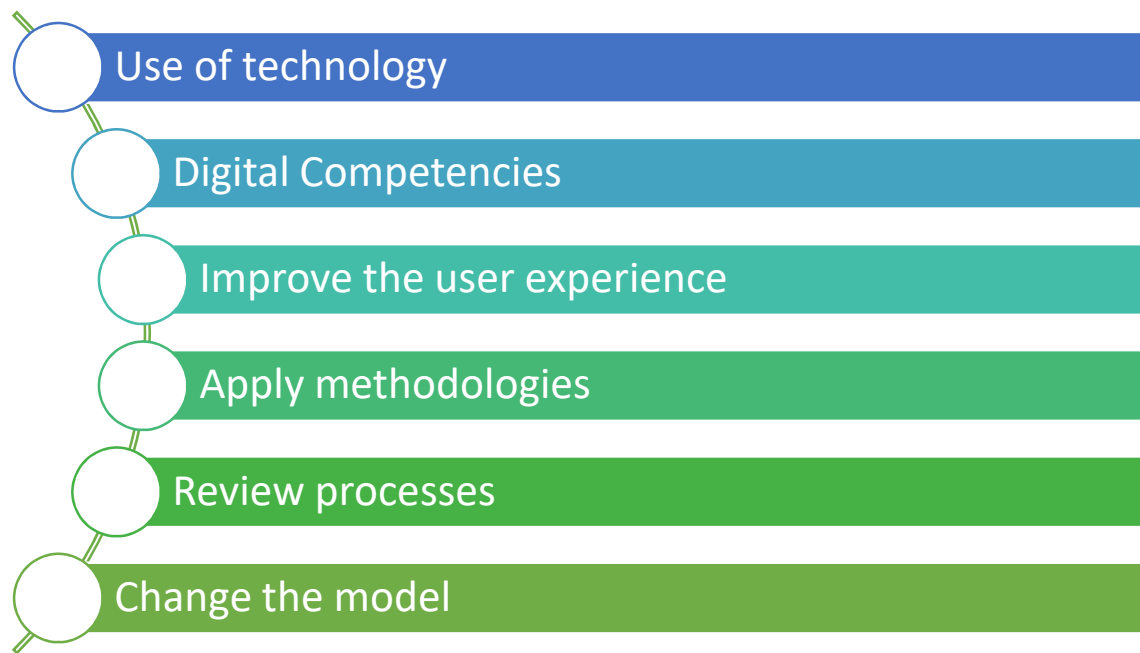


Figure 1. Factors for successful digitalization.

- Use of technology
 - Cybersecurity
 - Big Data & Analytics
 - Robotics (M. Learning & A. Vision)
 - Smart Solutions
 - Mobility & Wearables
 - Extended and Virtual Reality
 - Social Networks and eCommerce
 - 3D printing
 - Biotechnology
- Digital Competencies
 - Examine capabilities
 - Determine needs
 - Apply communication channels
 - Determine new roles
- Improve the user experience
 - Usability
 - Accessibility
 - Simplification
 - Design
- Apply methodologies
 - Observation
 - Strategy
 - Digital diary

- Digital Government
- Review processes
 - Socialize
 - Controlling impacts
 - Automate management
 - Streamline application
- Change the model
 - Evolve and streamline
 - Review and supplement
 - Industrialize
 - Globalize

The transformation to a Port 4.0 state involves measures to boost logistical efficiency in the areas of infrastructure, operations and service provision, improving environmental and energy sustainability, security and protection as well as the digitalization of intelligent processes and platforms.

Ports have always played a key role in the development of society, being a fundamental element in the economic development of the different countries and being in a strategic position at the global level. The current changes at a global level motivated by new forms of communication, behavior patterns, innovative technologies, etc. have meant that ports cannot ignore these new trends; they have to take an active role in this global change, being a main element of the transformation.

It is for all these reasons that this article attempts to analyze the most relevant aspects of the digitalization of ports in their eagerness to become “Smart Ports” or Ports 4.0.

A smart solution is the one that provides people with improvements in their personal and collective environment in relation to the territory where they live and their environment [7]. A smart solution is not the same as a digital solution, but Information and Communication Technologies (ICTs) are a good way to achieve a smart purpose.

To achieve that goal, digitalization is presented as a major factor for port development. In this paper, we analyze the main SWOT (Strengths Weaknesses, Opportunities and Threats) found in the process of the digitalization of ports.

2.1. Current Tendencies: Innovation, Digital and Smart

Nowadays, the denomination of “smart” is associated with several production and management devices and to logistics and distribution too. Thus, this qualification is used in different application fields. All of them are different and diverse, but the most important common characteristics of these devices or Smart Systems are based on their novel and more efficient way of working. The smart trend is consolidated in the port environment too. The ports’ need to become more intelligent is modifying their own operations [8].

Port authorities around the world are in a phase of continuous improvement to adopt new operating models that are more efficient, innovative and oriented to the service of users based on a Smart Port concept, or intelligent port, which allows for the sustainable management of port operations and services. To this end, they are using all the capacity and power offered by the enabling technologies within their reach, thus turning each port into a competitive, sustainable community with a flexible and efficient administration.

Motivations and available resources are the fundamental axes for the execution of automation processes and therefore of port digitalization [9]. Within this central scenario, a greater participation of the economic agents through transparency must be achieved, so that, together with a regeneration of the personal scenario, the benefits derived from automation can be obtained.

The critical point for the success of the execution is in the socio-cultural factors. Full automation will only be possible through dialogue and communication with the unions, involving them in the project and providing them with the information and training necessary for their retraining, so that the workers acquire the necessary skills in accordance with their abilities.

As already mentioned, the pillars are innovating, Smart solutions and organizational empowerment through digitalization [10].

Innovation in the port sector will require in this process the participation of citizens, the talent of people to improve creativity, prototyping to obtain the best referring to the action and the process of creating a model of a given product and the successive tests that are done with it to have tools to manage the change that will occur in ports.

The smart solutions associated with the port Industry 4.0 must bet on simplicity, sustainability, must be focused on efficiency and need to have people and territory in contact.

Organizational empowerment through digitalization requires a review of port processes; it will also require the use of digital technology, improving current digital skills [11]. We must be aware that new roles will appear in the process. This process of digital empowerment is based on:

- Having the power to make independent decisions.
- Having access to information and resources to make an appropriate decision.
- Having a wide range of options to choose from.
- An ability to exercise assertiveness in collective decision making.
- Positive thinking and the ability to make changes.
- An ability to learn and to enhance one's own personal or group power.
- An ability to change perceptions through democratic means.
- The ability to improve self-image and overcome stigmatization.
- The ability to participate in a self-initiated process of growth and continuous change.

A Vaio and Varriale's study [12] investigates the main implications of Industry 4.0 within seaports, outlining the role that accounting, control and reporting tools can play in managing information to make organizational and operational processes more effective and efficient in meeting the sustainability issue. The study shows the crucial role that new technologies play in accounting, and reporting tools in managing organizational and operational processes for sustainable smart ports.

The factors to consider for general digitized, innovative and smart ports will be divided into internal and external factors to the ports [13].

Internal factors are going to be more focused on efficiency and they are going to suppose a cultural change. The main examples are:

- The legal position of the public sector: What affects governance and the possibilities for introducing innovation?
- Companies and competitiveness: the existing gap between industrial processes and the excessive bureaucratization of companies and management.
- The ownership of the port, which complicates its management in a context of necessary interrelation.

External factors are more focused on growth and they mean new relationships. The main examples are:

- Logistics and the industry itself: increasingly large ships that make it difficult to moor and change calendars, forecasts and operations.
- The economy: globalization and economic tensions, as well as the current difficult geopolitical environment.
- Trade: new forms of trade that have broken traditional molds
- Some methodologies have been developed to study how digital platforms based on information technology infrastructure can rethink and redefine business processes in port organizations; Di Vaio & Varriale's study [14] compares two Italian port experiences adopting digital platforms (TPCS

and GAIA) and shows several benefits, including the reduction of time and paper documents in operational processes in relation to sustainability policy. This document aims to fill the research gap through an extensive analysis of the phenomenon and the empirical evidence.

2.2. Available Tools

The two main technologies applied in industrial systems and port systems are Internet of Things, to connect all the resources of a company and be able to obtain data and act on them; and Big Data, to analyze a large volume of data and be able to draw conclusions to optimize processes or even anticipate events.

Presently Big Data and Blockchain are the main tools to create smart ports, and were already developed for smart cities [15]. Data is collected anywhere, anytime. They are a double-edged sword, since they allow users to offer services adapted to them, but at the same time they move on the boundary between 'data search' and 'invasion of privacy'. Blockchain is already considered for all intents and purposes to be an innovation that in a few years will enter our lives [16].

Clearly, the fact of having a Port 4.0, comprises a series of advantages, such as having the merchandise located at all times, offering a greater possibility of control, which leads to greater efficiency in terms of load-unloading, storage and future transfer within the Hinterland [17].

For the movement of cargo, electric vehicles can be used, which contribute to reducing local emissions of greenhouse gases [18]. In addition, from the point of view of noise and possible spillage of machinery fuels, the impact that these factors can produce in a sensitive environment such as a port (from the environmental and landscape point of view) is reduced.

It is obvious that ports with a high level of computer development are more competitive and efficient than those without it. The implementation of these tools in port systems would not only make them more competitive with other ports, but also increase their viability and sustainability by creating efficient and flexible ports. In this way, they are infrastructures that will be able to work with greater volume of annual traffic, achieving a greater exchange of merchandise, and with it, greater income for the ports. In addition, and indirectly, the fact that an area grows co-commercially, generates an effect of 'rivalry' through which the adjacent areas also want to grow, creating an environment in which there is development that is positive both for the final consumer (who pays for a particular commodity) and for our regional scope, being a key point for the economy of the area. With digitalization, ports are looking for automation to make the supply chain more efficient and predictive [19]. In addition, intermodality is also pursued to develop a more sustainable management to reduce pollution, thereby gaining flexibility and agility. As was inevitable, Spanish ports have joined the process of digitalization, and little by little, the actions carried out in the ports, give them strengths that mark a clear competitiveness.

Linked to the Port 4.0 concept is the concept of synchromodality, according to which the stakeholders of the transport chain actively interact within a cooperative network to flexibly plan transport processes and to be able to switch in real time between modes of transport adapted to the available resources. This operation allows the customer to determine in advance the basic requirements of transport: costs, duration and sustainability aspects, which will be essential for decarbonization and logistics optimization in general [20].

Based on a systematic review of the literature, Fruth and Teuteberg [21] provides an overview of the current state of digitalization in maritime logistics, analyzes existing problem areas and shows potential for improvement. The results prove that it is essential to capture the development potential in order to benefit from the advantages of digitalization. However, the article concludes that the research is still in its initial stages and there is a lack of theoretical and empirical work, as well as explanatory approaches to obtain appropriate recommendations for action and restructuring. This is the most comprehensive article on the digitalization literature review to date.

3. Methodology

The analysis presented here has been carried out with a SWOT methodology, through the internal study of the weaknesses and strengths and the external study of the threats and opportunities of this digital transformation. To this end, a panel of experts has been developed who have been responsible for determining the SWOT matrix.

In order to establish the bases of the port digitalization process, it is necessary to take a picture of the current scenario. To this end, a panel of Delphi experts has been created to develop a SWOT matrix on digitalization in the Spanish port sector.

Spain is the European Union country with the longest coastline (8000 km). Its geographical location, being closest to the axis of one of the world's major maritime routes, also strengthens its position as a strategic area in international shipping and a logistics platform in southern Europe. The State-owned Spanish Port System includes 46 ports of general interest, managed by 28 Port Authorities, whose coordination and efficiency control corresponds to the government agency Puertos del Estado, a body answerable to the Ministry of Public Works that is responsible for implementing the government's port policy. The importance of ports as links in the logistical and transport chains is supported by the following figures: they handle nearly 60% of exports and 85% of imports, which account for 53% of Spanish foreign trade with the European Union and 96% with third countries.

In addition, the State port system's activity contributes nearly 20% of the transport sector's GDP, which accounts for 1.1% of the Spanish GDP. Moreover, it generates direct employment of more than 35,000 jobs and around 110,000 indirectly.

The internal weaknesses refer to the shortcomings and unfavorable limitations from the point of view of the port authority.

The strengths, conversely, describe all the favorable characteristics and abilities of the port authority.

From the external point of view, there are threats, which do not depend on the port itself, and opportunities. On the basis of these, appropriate strategies can be developed to combat these threats and take advantage of these opportunities.

Thanks to this SWOT matrix, managers can have a general idea of the difficulties, risks and benefits that logistical digitalization and technological information bring to the port sector and, therefore, to society in general.

The methodology adopted follows the scheme shown in the next one (Figure 2).



Figure 2. Description of the methodology followed in the study.

3.1. Preprocessing

- Step 1: Selection of process leaders
- 5 leaders are selected for the development and organization of the panels of experts and the stages of the SWOT matrix.
- Leaders correspond to the initials: NGC, BMS, ACO, MEI, FSF
- Step 2: International Benchmarking
- Benchmarking is becoming a central instrument for improving public sector performance. This development reflects that, under the right conditions, benchmarking can be an important driver of achievement. Benchmarking is an important tool for comparing and evaluating performance in a more objective way. It is intended to:
 - Create sustained pressure for improvement.
 - Expose areas where improvement is needed and reveal the underlying problems of an organization or group of organizations.

- Identify superior processes to adopt and gain a better understanding of best practices.
 - Focus on the links between processes and outcomes.
 - Test if the improvement has been successful.
 - The 5 leaders are responsible for collecting all international references and organizing them to work in teams with industry experts.
- Step 3: Checklist
 - All the elements that affect port digitalization in Spain must be gathered. It will be the leaders who will select the most relevant elements to work on with the panel of experts.

3.2. Delphi Method

- Step 1: Choose a facilitator or leader.
- Select your facilitator or leader for each of the 5 work teams, which will be neutral people within each team. It is helpful to have someone who is acquainted with research and data collection.
- Step 2: Identify your experts
- The Delphi technique is based on a panel of experts. An expert is any person with relevant knowledge and experience in a particular subject.
- Each of the leaders will face a team so that there will be 5 teams working independently on the development of 5 parallel SWOT matrices until the final consensus matrix is reached. It is difficult to work with many people and get them to agree, so it has been proposed to work in 5 groups.
- Step 3: Problem Definition
- What is the problem or problems you are trying to understand? Experts need to know what problem they are discussing, so be sure to provide an accurate and complete definition. In this case, it is about the current situation of digitalization in the Spanish port system.
- Step 4: First round team questions
- General questions are developed to gain a broad understanding of expert opinion on future events. Questions may come in the form of a questionnaire or survey. Compile and summarize answers, remove any irrelevant material and look for common views. This case uses a questionnaire that is based on the pre-checklist developed by team leaders.
- Step 5: Crossing previous SWOT matrices by teams
- The leader of each team will send the rest of the teams their first SWOT analysis to examine overlapping results.
- Step 6: Second Round Questions
- Based on the answers to the first questions, the following questions should delve deeper into the topic to clarify specific problems. These questions can also be sent in the form of a questionnaire or survey. Again, the results are compiled and summarized, any irrelevant material is removed and common ground is sought in the search for consensus building. The final questionnaire aims to focus on supporting decision-making. Concentrate on the areas of agreement. What do all the experts agree on?

3.3. SWOT Matrix

- Step 1: SWOT Matrix
- After this round of questions, it is expected that experts will reach a consensus and have a vision of future events. Findings are analyzed and plans are established to address future risks and opportunities for the project.

3.4. Crossed SWOT

- Step 1: Cross SWOT

- A Cross-SWOT is a derivation of the SWOT analysis, in which the factors are combined seeking potentiation (when both are positive or negative) or annulment (when one is positive and the other negative) between them.

4. Results

The developed Delphi panel was a conventional Delphi: this is the classic forum for prioritizing facts. It consists of a questionnaire sent to a group of experts, with a second questionnaire based on the results of the first one. Subsequently, the questionnaires are refined and the facts or proposals are defined to measure the accuracy or support of the participants. The experts assume the responsibility of making judgments and opinions, which are the core of the method. The criteria for their selection depending on the nature of the topic and the purpose of the study vary. Thus, experts were selected from a traditional approach, considering their level of knowledge, experience, publications and prestige in their field.

The experts assume the responsibility of making judgments and opinions, which are the core of the method. The criteria for their selection depends on the nature of the subject and the purpose of the study vary. Thus, sometimes experts are selected from a traditional approach (medical specialists or subspecialists), considering their level of knowledge, experience, publications and prestige in their field. Out of a total of 27 experts selected, 60% are from the theoretical field and 40% are from the more practical field of the port sector.

A careful selection of experts was made so that the results adhere to the reality of the Spanish port system. The Panel of Experts was composed of two groups: practical and theoretical (Figure 3).

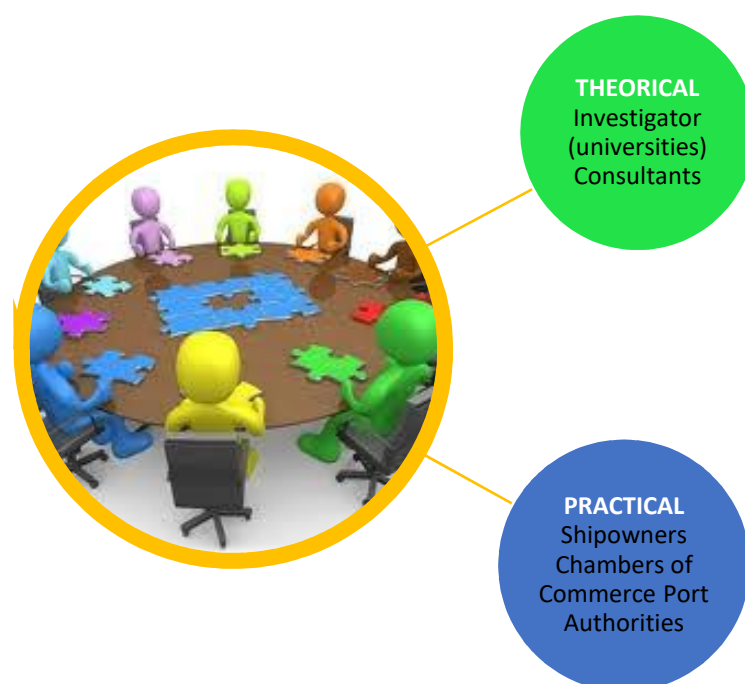


Figure 3. Expert Panel Classification.

Through the Delphi methodology panel of experts, the experts grouped the digitalization elements in the Spanish port system into a SWOT matrix (Table 1).

Table 1. SWOT Matrix (Strengths-Weaknesses-Opportunities-Threats matrix).

STRENGTHS	WEAKNESSES
S.1 Be a reference in the sector S.2 Consolidation of Spanish ports as connectors of port activity S.3 Decarbonization of ports S.4 Open Data S.5 Most advanced logistics practices and high solution capacity S.6 Reduction of operation and maintenance costs S.7 Increased safety	W.1 High costs of development and implementation of new technologies W.2 Human capital: Manual workers are under the direct influence of process automation inherent to digitalization W.3 Vulnerabilities or regression errors: Security and integrity of the company in achieving the 4.0 concept W.4 Lack of strategic planning W.5 Effects of the change in operations. W.6 Control and monitoring of the digital system W.7 Problem of heterogeneity of applications
OPPORTUNITIES	THREATS
O.1 New lines of business in developing markets O.2 Technological maturity O.3 Creating job opportunities O.4 Synergies port-city O.5 Efficient and predictive supply chain O.6 Insertion in the global Spanish chain on the CHAINPORT network	T.1 Political and institutional elements T.2 Poor integration of other actors in the port sector T.3 Changes in legislation, regulations T.4 Systems vulnerable to cyber threats T.5 Asymmetry with other modes of transport T.6 International financial uncertainty

4.1. Internal Analysis

The strengths and weaknesses of the issue of digitalization are related to the delicate relationship between new technologies at the service of infrastructures and its users. The factors were obtained from an internal analysis of the Spanish port situation.

4.1.1. Weaknesses

Weaknesses are negative points that the digitalization of the port will have, namely problems or situations that will arise and are detrimental to the port or port system.

W.1 High costs of development and implementation of new technologies: The digitalization and automation of processes in port terminals create a need for personnel who are sufficiently trained in the use of new technologies or in the handling of freight, especially when it comes to special loads or container terminals. In this respect, many jobs would be under-qualified or the company could lose control, as existing staff would have to be retrained or a new technical and specialized professional would have to be created by means of qualifications that provide the required skills and competencies in line with the new technologies implemented.

W.2 Human capital: Manual workers are under the direct influence of process automation inherent to digitalization. In addition, there is the problem of insecurity due to training, the lack of information on the human capital of the workforce commonly results in the reduction of training in digital matters. This is a problem focused on workers who perform mainly manual or mechanical tasks. By implementing a digitalization system, there will be functions that will no longer necessarily be performed by people. These people would be specialized personnel who would stop working; this would mean a loss of jobs that could have a greater or lesser impact on society and the economy. In the processes of conversion of content to digital formats, some people will have to be trained that do not have the minimum digital competences.

W.3 Vulnerabilities or regression errors: Security and integrity of the company needed to be able transition towards the 4.0 concept. The digitization of the ports makes possible the adoption of systems that increase the efficiency and transparency of the different agents involved and eliminates the need for paper documents, increasing security in general. However, blockchain systems can introduce vulnerabilities or regression errors by default as they become more complex or the information is

encrypted, so having a consistent way of managing and administering port security is key to ensuring its functionality and smooth implementation.

W.4 Lack of strategic planning: Despite participating in a globalized world with great technological advances, many ports have insufficient knowledge of the catalogue of possible solutions within the framework of digitalization that the market can offer them. Furthermore, there is a lack of information about how it works, where it is applied or what advantages digitalization can offer. This problem relates to two fundamental issues: the lack of perceptions of digitalization and the lack of accessibility to it. But do not be fooled, this does occur on a certain scale in ports, despite any claims to the contrary. The process of digitalization must not influence the development of port activity. This requires ad hoc planning in each port to cover the specific needs of each installation and process. The establishment of new systems requires adequate planning in the face of possible adversities. Many of the problems that may arise will not have precedents within the Spanish Port System, so the lack of experience of operators may cause an inability to react to these possible adverse problems.

W.5 Effects of the change in operations. The digitalization of ports would also make many jobs obsolete or unnecessary due, for example, to the implementation of recent and innovative loading and unloading systems controlled by monitors, so that the number of workers falls significantly and the rejection of modernization by the guild of stevedores would be more or less guaranteed. In this situation, it can be stated that, although in the long term the implementation of these systems would undoubtedly be a success, the process of change may be hindered by the discrepancies created among this guild and the different operator terminals, which could cause losses due to strikes or pickets until a fixed agreement is reached between the two parties.

W.6 Control and monitoring of the digital system: Digitalization imposes a dependence on a reliable, stable and secure digital system, since the entire operation of the port will depend on it. It must also be controlled and monitored to detect any failure no matter how small, as well as protected against external and internal agents that may produce irregularities.

W.7 Problem of heterogeneity of applications: The proliferation of digitalization presents the problem of heterogeneity of applications that are used globally. A consensus on the standard of use of open digital formats is presented as a clear weakness. In order to be able to digitize ports, first of all, the entire transport process must be globalized, i.e., all countries, ships and goods must use a common system to achieve full coordination of systems. In order to achieve this, there will be a common language for all logistics operators. The first step will be the digitization, through data conversion, meaning a shift from an analog format to a digital one, converting paper documents, photos, microfilms, etc.

4.1.2. Strengths

The main strengths acquired by Spanish ports as a result of the digitalization actions already implemented or under development in the different ports of the country are described below.

S.1 Be a reference in the sector: Digitalization means an increase in industrial power and differentiating port services that allows the port to become a main development node and provides a distinction within the sector. The Spanish Port System has matured and is modern, while the ports connected to the network constitute the logistical framework that allows the necessary transformations in the Smart, Green and Synchromodality sections. The evolution towards being more efficient, more functional, more technologically advanced and safer has been a constant challenge for ports in recent years. Over the years, tools and solutions have been developed that contribute to the safe optimization of many port processes.

S.2 Consolidation of Spanish ports as connectors of port activity: Consolidate Spanish ports as the ideal connection to attract not only import/export goods between Spain and the main neuralgic centers of the European economy, but also as a base for maritime transit, particularly coming from other continents such as Africa, America and Asia. Spain and its ports may continue to play a preponderant role in the context of world transport in the future, but it will depend on how we face and adapt to

the changes that the industrial revolution 4.0 will impose. Spain's privileged geographical position, located at the intersection of the main international maritime transport routes, and the rapid adaptation in recent years of its maritime infrastructures to the new requirements of world demand, with an installed capacity of one billion tonnes, places Spain in the Top 10 of the world rankings in terms of the quality of port infrastructures [21].

S.3 Decarbonization of ports: Spanish ports have already begun to apply bonuses of 50% in the port tax to those vessels that use LNG as fuel or that use gas in port for their auxiliary engines or are connected to the electricity grid [15]. In addition, infrastructure improvements and regulatory changes necessary to allow the provisioning of ships with alternative fuels under market conditions, and new bonuses associated with reducing emissions above the limits currently established, as well as the development of economic and fiscal incentives to demand. The search for a more sustainable port will lead to an improvement in environmental quality and therefore on the quality of life, not only of people, but also of the environment.

S.4 Open Data: Greater transparency in port management through public data opening platforms, also known as Open Data, makes the information held by the public sector, in this case the Port Authority, available to everyone in digital format, in a standardized and open manner. This allows all citizens and entities to have access to data on the administration that is being implemented of the port complex, ensuring transparency, efficiency and equal opportunities when creating value.

S.5 The most advanced logistics practices and high solution capacity: Automated terminals allow ports to manipulate containers more efficiently by planning storage according to the collection and transshipment times. This reduces unnecessary movements, reducing operating times and therefore increasing productivity. On the other hand, while humans are susceptible to fatigue or distractions, automated systems always operate at the same performance, regardless of unforeseen events. This makes ports more reliable in terms of delays and unforeseen events, which are often due to human errors that could have been avoided. It also prevents the uncertainty that can result from situations such as strikes.

S.6 Reduction of operation and maintenance costs: Automation of port systems leads to a reduction in work force, significantly reducing the costs of operations. Automated systems only require software and a port worker specialized in their control, unlike traditional systems with a lot of less specialized labor. Automation brings with it an increase in electrical equipment by reducing combustion equipment, which reduces maintenance costs and the likelihood of accidents. Automation also leads to a reduction in damage to equipment and loads due to the efficiency of the system, which contributes to lower maintenance costs.

S.7 Increased safety. Automation at the port level increases the safety of the different terminals, as artificial intelligence better controls who enters and leaves a port. All doors are automatically controlled, and there is an entry system of optical recognition, fingerprints or voice, which make the port much safer. On the other hand, this allows for greater control of the loading and unloading processes. In addition, it avoids losing documentation when everything is digitized.

4.2. External Analysis

In this particular case, threats and opportunities are opposite sides of the same coin. They are different issues, but simply two possible endings for the story that we are living through.

4.2.1. Threats

T.1 Political and institutional elements: The policy context is important for understanding Smart Ports initiatives, which includes political and institutional elements. The transformation towards digitalization of ports requires the interface of technological elements with political and institutional elements. Under the political dimensions, historically, interactions between the public and private sectors have been quite complicated. The different modes of transport have to maintain a close

relationship in order to achieve global digitalization, involving political and institutional elements in the objective.

T.2 Poor integration of other actors in the port sector: The process of change towards the new port system and the modification, or even replacement, of facilities can lead to an initial slowness and inefficiency in port operations. This can involve take advantage of competing foreign ports or retaining some of the current customers of Spanish ports. Port authorities may feel threatened by the different implementation of the digitalization system in the different Spanish ports. Not all ports are equally prepared for digitalization and a better and faster reception of new technological processes by a given port may reduce the attraction of current customers from another port that is within the Spanish Port System. Poor integration of other agents can occur in the port sector through the “Smart Ports” strategy. Some ports have barely begun the simple digitization process.

T.3 Changes in legislation, regulations: Inconsistencies in national and regional policy rules and regulations cannot help to expand smart city initiatives. The use of Big Data and the massive use of data has legal implications that are controlled by different administrations in each country, community or region. Changes in legislation, regulations, the right to protect privacy, the impossibility of storing personal data and future changes in legislation may mean that this digital transformation may not be as useful as previously thought. Ultimately, the usefulness of this digitalization will be mainly conditioned by the country that places the greatest restrictions on the storage and use of these data. It is useless for ports and ships to have a lot of information if its use is not allowed in the country of destination.

T.4 Systems vulnerable to cyber threats: From Spanish ports through the internet, the digitalization of our new world and the development and progress of technologies show that we are much more vulnerable and sensitive to attacks through cyberspace. Today there is something we all know called Big Data, an intangible cloud lodged in the air and available to all inhabitants of the world. This can generate big problems, as private data are the engine of the 21st century. Our data is very valuable for all companies. Dependence on technology, both in ports and on seagoing ships, is increasing. Crew numbers are decreasing as computer systems are used for navigation, fast unloading, handling and tracking of goods in ports. Unfortunately, these systems are also very vulnerable to cyber threats. Each hack can cost ship owners millions of dollars, and in some circumstances could even ruin the national economy.

T.5 Asymmetry with other modes of transport. As can be expected, digitalization is not only reaching maritime transport; both land and air transport are advancing every day in order to achieve competition. It is in passenger transport that most competition is offered to maritime transport. However, in the transport of goods, the railways and airplanes are still struggling to make their way. However, there is no doubt that, for the correct digitalization of transport, it is necessary for collaboration and participation involving all the modes that form part of the chain to occur. Cost savings, greater agility in the entire supply chain and improved operational efficiency are the main advantages that the logistics sector sees in the digitization of documents related to the transport of goods, which affect all modes of transport.

T.6 International financial uncertainty. Lack of budget and resources due to depleted public finances slowing down public investments. In addition, there is a lack of appropriate and systematic methodologies and metrics to report and verify investment returns. The financial situation, the lack of credit and regulations on financial institutions to reduce risk exposure by creating more solid deposit bases are limiting available cash flows, which slows investments in port digitalization actions.

4.2.2. Opportunities

Opportunities are potential areas in which the port can identify potential growth, profits and market share. It is therefore a point of possible positive development that affects the port externally.

O.1 New lines of business in developing markets: The growth of international trade in a globalized world, therefore opens up a business opportunity for ports to open new lines of business in markets in

developing countries whose booming economies demand more and more products of a high level and price (technological products, jewelry, sports cars, advanced weaponry, etc.) and not of primary necessity, as was happening in the past. In addition, digitalization makes it possible to manage goods and passengers more efficiently, thus managing to transport more volume together, favored by the scale factor, further improving competition.

O.2 Technological maturity: Industrial productivity is improving, allowing the actors involved to provide a wide range of products and services to the ports. This can help ports to venture significantly into products and services with a high degree of immediacy.

O.3 Creating job opportunities: The convenience of being able to work from home could be accompanied by continuous monitoring. The hope of being able to work less could be stifled by the possibility of working anywhere and at any time. New skilled jobs are likely to wipe out other jobs, which will also increase competition and consequently diminish individual earnings. What is certain, however, is that companies will not lose out. On the contrary, companies that manage to keep pace only have to win in this era of innovation.

O.4 Synergies port-city. The digitalization of ports in relation to the development of Smart Cities allows a synergic interaction between both institutions, their governments and their citizens. Digital ports are by and for people, and are therefore the key agent in their future development. A better relationship with the city and the integration of the citizen is needed: digital platforms allow the citizen to know the opportunities offered by the port, as well as the creation of wealth that it represents for the entire population. In the same way, the citizen can transfer suggestions or proposals to the port management that translate into improvements for the day-to-day citizenship, promoting a better coexistence between the port and the city.

O.5 Efficient and predictive supply chain. More sustainable management to reduce pollution, gaining flexibility and agility. Intelligent ports reduce transport costs and consequently their connections are much more attractive; they offer a very important competitive advantage over other enclaves. In this context, technology and innovation can become key elements to provide real-time information, offer new services from the data flow and digitize processes. Integration with the city and hinterland-foreland would reduce truck queues and traffic jams. To deal with them, it would be key to share, merge and analyze the data with a view to optimizing processes and performance, for which Big Data would be paramount.

O.6 Insertion in the global Spanish chain on the chainPORT network. The objective of this network is to establish a global network of intelligent ports that are leaders in the development and implementation of technological solutions to share knowledge, create a basis for the joint development of innovative and future-oriented solutions and develop common strategies for the port sector.

4.3. Expert Panel Consensus

Although a conventional Delphi model has been applied, for each working group a real-time Delphi has been applied, it is characterized as a shorter variant where the process takes place during the course of a meeting through mechanisms to summarize the responses given immediately. The meetings were held in face-to-face groups, the consensus building dynamics were through dynamic meetings and not through a questionnaire process.

Consensus among experts occurs when experts consider that an indicator is sufficiently representative to be part of one element of the matrix (S-W-O-T), which cannot be represented by another higher order indicator and which is not included within the elements of another indicator.

In the SWOT matrix (Table 1), only those elements where there was a high degree of consensus were included, i.e., those points where 90% of the experts reached consensus, and those where more than 98% reached consensus are written in orange in Table 2, and represented as elements of maximum consensus.

Table 2. Elements of maximum consensus of SWOT Matrix (written in orange).

STRENGTHS	WEAKNESSES
S.1 Be a reference in the sector S.2 Consolidation of Spanish ports as connectors of port activity S.3 Decarbonization of ports S.4 Open Data S.5 Most advanced logistics practices and high solution capacity S.6 Reduction of operation and maintenance costs S.7 Increased safety	W.1 High costs of development and implementation of new technologies W.2 Human capital: Manual workers are under the direct influence of process automation inherent to digitalization W.3 Vulnerabilities or regression errors: Security and integrity of the company to transform to concept 4.0 W.4 Lack of strategic planning W.5 Effects of the change in operations. W.6 Control and monitoring of the digital system W.7 Problem of heterogeneity of applications
OPPORTUNITIES	THREATS
O.1 New lines of business in developing markets O.2 Technological maturity O.3 Creating job opportunities O.4 Synergies port-city O.5 Efficient and predictive supply chain O.6 Insertion in the global Spanish chain on the CHAINPORT network	T.1 Political and institutional elements T.2 Poor integration of other actors in the port sector T.3 Changes in legislation, regulations T.4 Systems vulnerable to cyber threats T.5 Asymmetry with other modes of transport T.6 International financial uncertainty

It can be seen that the elements of the matrix with the highest consensus of indicators are: Weaknesses and Opportunities, and the lowest are Strengths and Threats.

With the data analyzed, it is necessary to enhance the strengths and reduce the weaknesses, exploiting the knowledge of threats and opportunities. For this purpose, the experts carried out a crossed SWOT analysis in which they face: Strengths + Opportunities, Strengths + Threats, Weaknesses + Opportunities and Weaknesses + Threats indicating which are the most important actions to be developed.

Strengths + Opportunities: It is not necessary to say that, because of its position, Spain can become a world power, like Great Britain and the United States. Spanish is the third language in the world. The Iberian Peninsula dominates both the Mediterranean Sea and the most important oceans, which project it into a dominant position in a future ruled by transport infrastructures and technology. The Spanish ports are not yet at the level of sustainability of the port of Antwerp, in Belgium, or the port of Hamburg. However, Spain has many more resources and it is normal to move more slowly than countries with fewer structures to intervene.

Strengths + Threats: With advance planning, you can retrain your workforce so you do not have to reduce it. Moreover, reducing human presence for the benefit of intelligent machines is precisely one of the mistakes that scientists and researchers warn us about the artificial intelligence should help us, not replace us. Moreover, in this intelligent new world, in order to preserve it from the decisions of isolationist countries, it would be possible for Spain to form its own community with its former colonies. On the other hand, the new specialized technicians, the young people who have studied and seen the world can certainly overcome walls and old conflicts that have already ended.

Weaknesses + Opportunities: It will be impossible to take full advantage of the opportunities offered by each position and technology, unless a single regulation is issued to help the various bodies co-operate with each other. In addition, it is very important to ensure that people grow together with the country; this means both students and professionals must already be active in their sector. As far as emissions are concerned, Spain is on the right track.

Weaknesses + Threats: It will be the inadequacy of the current operators, together with the increasingly voiceless trade unions, to decree a loss or replacement of the labor force. For this, it is necessary to discuss the problem and plan a solution. The biggest concern is that people do not notice digitalization, that they are left behind. In order to create an intelligent city, the city must grow along with its infrastructure; likewise, citizens and especially workers must be integrated into this new

project. It is necessary to provide refresher courses and always have a plan B. The most damaging threat is the one that is not foreseen, as it blocks the whole system.

Below is a map of global perspective from today for the short and medium term with the elements most highlighted by the experts, differentiating between those elements that put innovation in value and those that only involve imitation in value (Figure 4). Figure 4 summarizes 3 types of ports according to the degree of digitalization and its expected evolution over time: Group 1 (innovation in value) is formed by those that offer unparalleled value in the market. They are sources of growth and profitability. At the other end, there are Group 3 ports (imitation in value), Group 2 (value improvement) are those ports that are in the middle. The colors represent the same element and the width of the circle identifies the level of development of that element. The elements are accompanied by the signs +, and = that indicate their evolution in time. Proportional symbols are widely used in the field of quantitative mapping. They are fundamentally based on a very simple idea; a shape is selected in this case a circle (the circle, possibly because of its compact and easy to construct shape, is also visually more stable than the others) and its size is varied from one point to another, in proportion to the quantities we want to represent. In the mathematical scaling of the circles, it happens that there is a general tendency to underestimate the sizes; that is, a circle is not perceived as being twice as large another one when geometrically it is, this underestimation grows with the size of the circles, and it has been compensated for by systematically increasing the area of the circles according to perception factors. This leads to a representation of easy understanding by the user, since the association of quantities to sizes is very intuitive, as an example the digital skills indicator has a small circle size in value improvement and grows to today a short team, so the symbol + appears and remains constant at long term (does not evolve) so it appears in symbol =. So the proportional symbol on one hand locates the data, and on the other hand gives the information of quantity relative to that point. In the case of control tools, since the circle has a much bigger size for the short team, it will be necessary to emphasize more on this indicator to innovate in the market, but in long term, it decreases and therefore the symbol - appears.

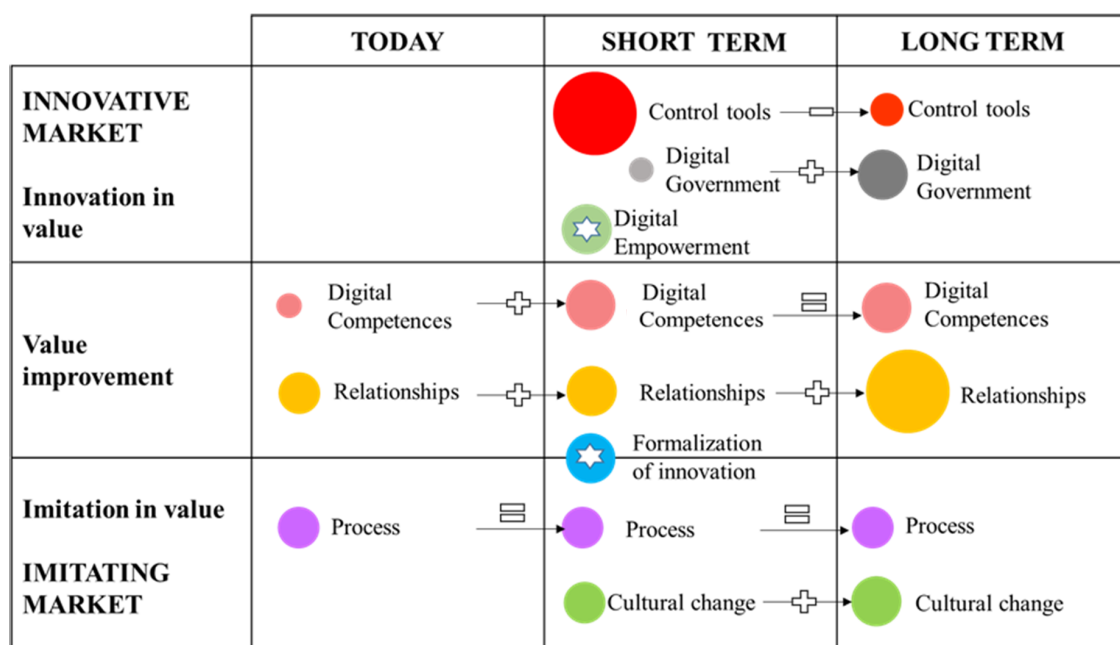


Figure 4. Port groups by degree of scanning.

The experts noted a special impact on the future of digitalization in the paradigm shift that will involve this process in ports, transparency in the process and data will mark the next steps having to pay special attention to cybersecurity.

5. Conclusions

The adoption of information systems and technologies has repeatedly paved the way for the modernization of seaports. Despite the growing importance of information systems in solving current and future challenges, little attention has been paid to this issue in the area of maritime logistics.

The pace of digitalization continues to change logistics processes in modern seaports. The success of the digital transformation lies not only in the adoption of modern technologies and advanced methods, but especially in the adaptation of organizational structures, which in the Spanish case is highly segmented into port authorities, which operate independently, with management autonomy. In this sense, it is appreciated that digital initiatives, despite being innovative and with a specific purpose, can easily fail if the different requirements, perspectives and implications for individual actors are not properly considered, especially in complex ecosystems such as seaports. Strategy alignment and cooperation between stakeholders play a crucial role in transforming port operations with common objectives; for the Spanish port authorities, further work is needed to create a framework for collaboration and common tools. In this context, intra-, inter- and meta-organizational perspectives must be considered in order to analyze the options, as well as the costs and benefits resulting from digital transformations. To construct and evaluate different forms of cooperation, we observe that more research, especially quantitative research, is needed.

The Spanish Port Authorities are in a phase of continuous improvement to adopt new operating models, more efficient, innovative and oriented to the service of the users from a Smart Port concept, or intelligent port, which allows the sustainable management of port operations and services. To this end, they are using all the capacity and power offered by the enabling technologies within their reach, thus turning the port into a competitive, sustainable community with a flexible and efficient administration. In this context, the lack of training of the port authorities' personnel will be one of the greatest handicaps.

The main short-term measures should focus on (6 months–1 year):

- Improving the training and information given to staff in the context of new technologies soon to be introduced in ports.
- Increasing the collection of information from other ports: this measure could be linked to an increase in infrastructure investment. This is due to the fact that part of this investment could be used to create a team specialized in the search for patterns that have been used by other ports to bring their ports to reach a Ports 4.0 status.
- Increasing transparency: Increase the regular holding of information days in the sector, development of regulatory specifications for general services and information on the Internet about available areas and uses. Also, the relationship and exchange of data between the different port authorities in which independent projects must be developed.
- Implementing Blockchain: this would allow for the strengthening of connections between the different agents involved in this sector, since the objective of this platform is to create a global data exchange network, thus speeding up the procedures for the purchase and sale of goods in a more secure manner.

The keys to obtaining maximum efficiency through digitalization will be based on a cultural change, a new vision of the port sector, especially in the face of innovation:

- A real commitment to port sustainability: this will be necessary in port processes to go hand in hand with digitalization
- New governance and public-private, social and labor relations: the new appearance of professional profiles as well as the involvement of the private sector in port management and planning will require new alliances in order to develop port digitalization. The digital transformation presents a set of new opportunities for port development, as a result of the evolution and democratization of technology. This transformation is not only technological, but it also implies the provision of

new skills to people and the implementation of organizational innovations that will affect both processes and the very model of business and service provision.

- Reconfiguration of the port map, changes in the global TOP and logistical integration and interaction of geopolitics: the degree of port digitalization is different in each of the ports, which is why the ports that best adapt to the new digital processes will be the new TOP ports, which could modify current trade patterns. The allocation of new technologies will promote the deployment of comprehensive technology platforms, which standardize and integrate the various systems that are part of a port, to make it a more efficient, innovative and user-oriented space from a concept Smart Port, or intelligent port.
- Technical progress and automation: implementing new technologies in all port areas, allowing sustainable management of port operations and services, using all the capacity and power offered by information and communication technologies.
- New trade and port activity: changes are expected in logistics and transport parameters, including the elimination of intermediation and the improvement of modal interchange, in order to improve the competitiveness of transport chains, based on automation and robotization.

Above is a map of global perspective from today for the short and medium term with the elements most commonly highlighted by the experts, differentiating between those elements that put innovation in value and those that only involve imitation in value (Figure 4).

The experts noted a special impact on the future of digitalization in the paradigm shift that will involve this process in ports, transparency in the process and data. This impact will mark the next steps for progress, while having to pay special attention to cybersecurity.

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