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Diagnosis of the digitalization of the Spanish ports: End to End tool

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ABSTRACT

The adoption of IT/IS has repeatedly paved the way for the modernization of maritime ports. Despite the growing importance of information systems in solving current and future challenges, little attention has been paid to this topic in the area of maritime logistics. The march of digitalization continues to change the logistics processes in modern seaports. This study presents a tool called End to End Tool that allows to obtain a picture of the past, present and future situation around the digitalization of Spanish ports, it is a model of observation of the environment and the most representative factors. It allows to know the reality of the conditions of the port environment where the digitalization has been thought to be developed, moreover, in its final phase it allows to establish the possible scenarios of digitalization for Spanish ports, highlighting as main conclusion that there is still a long way to go in digitalization, such as making an immediate conversion to digital, intelligent and green ports, which optimize the existing infrastructures with a plus of capacity thanks to the intelligent management of spaces.

Keywords: End to End Tool, digitalization, Port 4.0, Spanish Port System

1. INTRODUCTION

Since the inception of containerization in the 1960s, the adoption of information technology and information systems has become an indispensable success factor for port competitiveness, facilitating communication and decision-making to improve visibility, productivity, efficiency, and safety in port procedures that are affected by various conditions. In addition, better integration of government agencies to standardize and harmonize information procedures is becoming increasingly important.

Especially the role of ports has changed dramatically from their traditional function, connecting sea and land through loading and unloading operations, to an essential part of global logistics networks that manage the flow of cargo and offer value-added logistics services in an efficient and effective way. In a safe and environmentally friendly manner.

Today, we are immersed in the fourth industrial revolution or Industry 4.0. With digitalization, ports are seeking automation to make the supply chain more efficient and predictive. In addition, intermodality and the development of a more sustainable management to reduce pollution, gaining flexibility and agility are also being pursued.

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 a concept of industry in which intensive use is made of the Internet and cutting-edge technology in order to develop smarter and more environmentally friendly industrial plants and processes. It involves production chains that are tightly connected to each other and to markets.

In today's world, we are talking about Smart, 4.0, digitalization, innovation, etc. With the means available, it is possible to change the functioning of the entire global system. This is inevitable, on the one hand, because technological progress cannot be stopped; on the other hand, because the world requires it. The time has come to make (and implement) more sustainable choices that society demands, more oriented towards future life rather than just based on economic profit. However, this process is not without complexity and problems that hinder its implementation in the Spanish port sector.

The aim of the study is to develop a new methodology "end to end tool" that allows to obtain a picture of the past, present and future situation around a business idea, in this case the digitalization of Spanish ports, it is a model of observation of the environment and the most representative factors. It allows to know the reality of the conditions of the port environment where the digitalization is planned to be developed, and in its final phase it also allows to establish the possible scenarios of digitalization for the Spanish ports, in order to evolve beyond the observed reality.

2. ART FRAMEWORK

Today, we are immersed in the fourth industrial revolution o Digital transformation is of major importance in the business world with important impacts on any of its sectors. Here, ports and logistics within maritime transport are considered to exemplify these developments. That is, as players in global supply chains, seaports are particularly affected by technological change.

Due to the high requirements in the logistics sector, e.g. with regard to costs, efficiency, safety and sustainability, digital innovation is essential to maintain competitiveness.

Modern seaports play an important role in ensuring efficient and secure cargo flows in global logistics networks. In addition, ports offer various types of valuable logistics services. The efficiency and safety of the related cargo flows are highly dependent on the associated information flows.

Digitalization is pushing the maritime industry beyond its traditional boundaries and provides many new opportunities to improve productivity, efficiency and sustainability of logistics. The concept of smart ports, for example, 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 to promote information exchange and better coordination and collaboration, often seen as a bottleneck in highly competitive environments. In addition to many new opportunities, important issues and especially economic problems arise.

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

Port terminals will play an important role in the development of these ports. Years ago, they started to modernize especially in container traffic, terminals that increased their productivity by automating part of the machinery, which carried out the unloading of ships.

Therefore, the current phase of digital transformation is very much 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. This may involve advanced pre-processing and data analysis to extract information and insights, which can be used in advanced planning and decision support systems. However, the success of digital transformation lies not only in 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".

In general, information systems already cover almost all maritime logistics activities mainly used to acquire, process, exchange and analyze data at an increasing volume and pace through the application of advanced technologies and methods.

Within the current trends towards digitalization, innovation plays a fundamental role, this must be a controlled process, involving a cultural change, where flows and processes have to be recreated to generate open innovation. Innovation must be formalized and incorporated into the culture of the company, and ports as an industry-company are no stranger to this process. The management of the R&D&I model associated with innovation must be systematized, verifiable, auditable and measurable within the port environment. In order to guarantee the control of innovative activities, control tools must be developed. There is still a long way to go within the port sector to control the management of the change from initiatives to projects.

Ports have played a key role in international trade since their existence. However, their strategic position has changed significantly over the last twenty years, during which time there has been an evolution towards more and more demanding requirements in terms of operational and management standards.

At the same time, the global scenario of port competitiveness has undergone significant changes. All the world's major ports have witnessed a transition in the focus of their economic development model from a commitment to extensive growth to a commitment to intensive growth. The former put the emphasis on increasing the labor force or its skills, as well as

infrastructure improvements and increased investments in capital and resource mobilization. Intensive growth, on the other hand, focuses on acquiring an innovative attitude, capable of progressing towards new ideas and values that drive improvements in the efficiency of the system, even if this means breaking with traditional patterns. This path towards the discovery of new and better methodologies makes it possible to perfect the exploitation of the resources usable by a specific economy. Moreover, it opens up a new path towards sustained developments and improvements, and important qualitative leaps in levels of well-being.

This change in the vision of port operation allows progress towards more transparent management models and broadens the focus of interest to other areas that favour port competitiveness beyond operational improvements. To facilitate this transformation, ports must make effective use of digital resources and strengthen their collaboration with industry, thus fostering added value in port activities.

All in all, it can be said that business model transformation and innovation are two imperatives for ports around the world in order to seize the opportunities offered by yet unknown markets.

2. 1. Today's ports. Management trends

Throughout history, ports have been another reflection of the industrial and technological evolution taking place in the world. The different technological advances have led to changes in the management models, relationships and types of jobs offered in the port environment.

In the first instance, progress was aimed at improving construction procedures, rolling stock, and infrastructure design. Subsequently, once the required standards in these aspects were achieved, other factors such as strategic planning, logistics and marketing began to be promoted. A key element for port development around these fields was the growth of international freight transport, which led to increasing demands on delivery times. In this way, the complexity of port activities increased and new types of relationships were established between them and with their environment.

This port evolution has had repercussions on the management models. Thus, ports can be classified according to their main functions and characteristics over time.

The first generation ports presented the simplest requirements. Their functions were limited only to the transport of small quantities of goods between land and sea modes, with an influence limited to the local level. They lacked development strategies, storage management, and the roles of agencies and administrations were not well defined.

With the installation of industries in port environments comes the next generation of ports, which can be categorized as "industrial ports". Although their main activity continued to be the service of ships and goods, the recognition of the economic potential of these infrastructures led to the appearance of value-added activities, such as the installation of heavy and processing industries in the vicinity of the ports. This behaviour responds to the approach of incipient development and expansion strategies, which also sought to bring the ports closer to the users and to establish relations with the city.

The evolution continues up to the third generation ports. These ports are evolving towards more sophisticated logistics systems, in which information processing and telecommunications generate added value. The implementation of information systems improves the distribution activities of goods, encouraging the creation of more efficient logistics platforms. In addition, development strategies are becoming more commercially oriented, with better coordination of activities, creating a more cohesive and active port environment, and forging closer relations

with the city. Next, there are the fourth generation ports, which are called "network ports". A network port sets its objectives on "door to door" transport, for which it integrates itself as an element in the logistics chain together with the other operators. This behavior requires the presence of logistics platforms in the form of dry ports in areas of high consumption or production. These platforms must be connected to the seaports by means of rail and road lines that allow the transport of large volumes of goods at competitive prices. Technology remains a key element of development, and the projection sought continues to be internationalization.

As early as 2010, there was already talk of fifth generation ports presenting strategies of internationalization, diversification of activities, or telematics networks between the various port areas, as well as the so-called network ports, which are already integrated in door-to-door logistics chains.

Thus, for the management of maritime traffic, the European Mona Lisa 2.0 project, which is in its final phase of development and implementation, is beginning to speak of sixth generation ports, which commits port facilities to anchoring the maritime traffic sector in the digital era and, in this field, to providing more safety, more efficiency and greater environmental protection.

This new model of ports is linked to the concept of Smart Cities or intelligent cities in which ICT, the optimization of resources, security, mobility and transport, together with the environmental awareness of citizens are parameters against which they are measured [28].

The port must be part of this environment and therefore the idea of a sixth generation port would be what will be seen in the near future in ports located with cities important for the maritime industry, the Smart Port & City.

It must be a Port which is directed towards energy self-sufficiency, which is committed to an environmental policy in terms of waste, recycling, water saving and the use of renewable energies for all the companies working in the port or in the areas of logistical activities.

Initially, the introduction of any alternative energy source takes place at a slow pace, as the necessary infrastructure has to be put in place to make it readily available. In addition, the introduction of any new fuel is likely to take place first in regions where alternative energy supply is guaranteed in the long term.

Due to the uncertainty related to the start of the development of the appropriate infrastructure, it will start to be used in smaller vessels designed for short sea trade. As more mature technology and infrastructure development becomes available, new fuels will start to be used for larger vessels.

Renewable energy sources such as solar and wind are not yet seen as viable alternatives for propulsion of large commercial vessels. At present LNG represents the first and probably the alternative fuel. The introduction of batteries on ships to assist propulsion and auxiliary power demands is also a promising source of low-carbon energy.

The pace of development of other alternative fuels, such as biofuels produced from local biomass, will accelerate and may soon be complemented by LNG or electricity.

It is likely that, from 2030 onwards, the acceptance of different biofuels could become the norm in different parts of the world, the problem is that they must be produced in large volumes and at a competitive price for large ships.

It will be important for the port-city itself to invest in research and development to improve terminal efficiency, port management and energy self-sufficiency, involving the entire port community in this regard. Investment in research and development allows much faster progress in this direction.

This whole process of improving the quality of port operations through technology has led to a progressive liberalization of the activities carried out in the ports of the Spanish State-owned Port System. In order to ensure that these activities are carried out in a way that respects free competition and avoids the formation of monopolies, the Port Authorities have been given the capacity to act on these issues. Furthermore, they have the responsibility to promote innovation and the development of strategies aimed at improving port competitiveness.

2. 2. Ports 4.0

Spanish State Ports has generated a plan called "Plan Puertos 4.0" through which a fund is provided to boost innovation in the port sector. The "Ports 4.0 Fund" is a new inter-port compensation fund aimed at promoting and actively incorporating disruptive innovation as an element of competitiveness in the Spanish public and private logistics-port sector (www.puertos40.es).

The main objective of the plan is to "promote and incorporate disruptive or incremental innovation as an element of competitiveness in both 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 innovation with external innovation at the level of the port system and the port community, entering into national and international innovative ecosystems, having a corporate start-up incubator in the port-logistics sector and accessing funding and facilitating the attraction 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 port-logistics sector.

This is expected to achieve the consolidation of a network of emerging companies and new lines of business that develop innovative products for the logistics-port sector, as well as the practical application of new innovation strategies, promoting the adaptation and transition of the logistics-port sector to Industry 4.0. We are currently immersed in the fourth industrial revolution or Industry 4.0.

This technological current requires moving from electronic ports to interconnected ports, which will produce changes in port governance models, not because there is 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.

The transformation towards port 4.0 involves measures to boost logistics efficiency in the field of infrastructures, operations and service provision, the improvement of environmental and energy sustainability, safety and security, as well as the digitalization of processes and smart platforms.

Ports have always played a key role in the development of society, being a fundamental element in the economic development of different countries and being in a strategic position worldwide. The current global changes driven by new forms of communication, behavioral patterns, innovative technologies, etc. have meant that ports cannot remain on the sidelines of these new trends; they have to take an active role in this global change, being a major element of the transformation.

3. METHODOLOGY

In order to develop the End to End tool as a business idea associated with digitalization for the Spanish port system, the methodology shown in Figure 1 is developed.

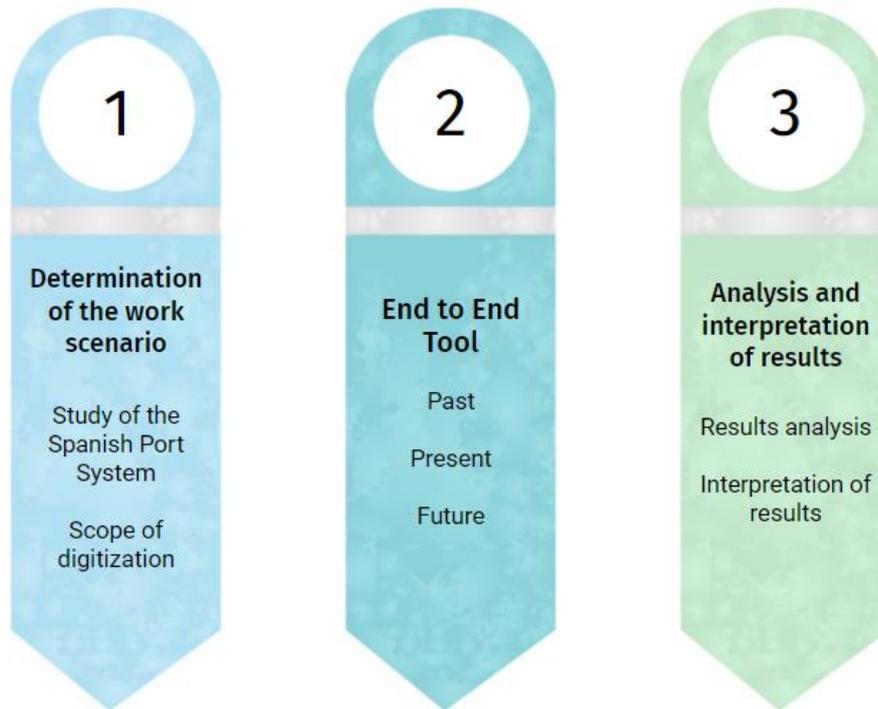


Figure 1. Methodological schedule

3. 1. Determination of work framework

The methodology begins with a complete study of the Spanish port system in terms of the digitalization process being undertaken. The scope of digitalization in the different ports of the Spanish port system is then studied in detail. This first step ends with the creation of the content database, for which it is necessary to carry out a collection of information and data, which can be both categorical and numerical. The data collection will be carried out using different sources.

3. 2. End to End tool

End to end tool has been designed as a tool that allows to establish the task and the path that organizations must follow to achieve the planned goals, taking into account the changes and demands imposed by their environment. In this way, starting from the environment where the project has been thought of, the past can be known, and then the present is studied through how, why, what for and who, the motivations and capacities necessary to advance and, knowing the detail of the work group, it is necessary to determine the factors and conditioning factors that alter or intervene in this environment, starting from the macro environment and then studying the micro environment.

It is necessary to understand the environment in which the project has been designed, as well as the elements outside the project that may alter future decisions and strategies formulated in order to plan for the future (Figure 2).

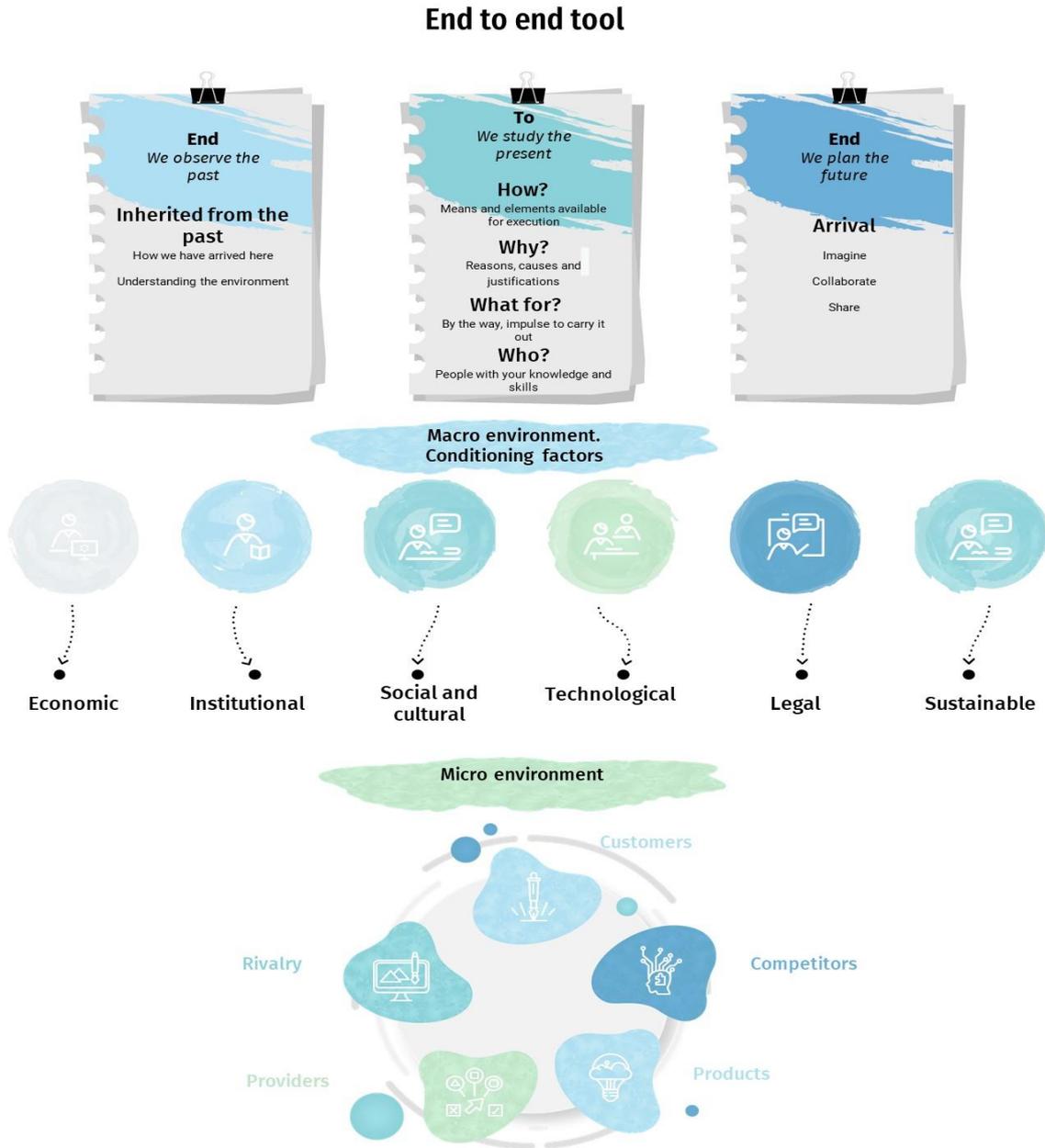


Figure 2. End to End Tool

3. 3. Analysis and interpretation of results

The analysis of results basically consists of answering the objectives or hypotheses set out from the measurements made and the resulting data. It consists of dividing compact information into different elements that will be reviewed and analyzed one by one.

4. RESULTS

Any organization is on a quest to be successful. For this reason, it is essential to chart a clear path to achieve the planned goals. However, to chart this path does not only mean establishing the point to be reached, which is the definition of strategy, but it also implies setting out the steps to be taken to reach that goal. This is precisely what organizational planning is all about. In order to obtain results, as shown in Figure 4, which represents the methodology, the first step is to determine the work scenario. To this end, a complete study of the Spanish port system has been carried out with regard to digitalization and its associated concepts: automation, synchromodality, smart port, ports 4.0, etc. A study was also carried out on the digitalization projects developed in Spain and on the scope of each of the port authorities. Subsequently, all the available information was classified, distributed to the work team and a content database was created.

The next step, End to End Tool, starts with an analysis of the past, moving on to the present and the arrival is the future. The tool does not aim to eliminate risks, it only identifies them and provides tools for better decision making in each case. The results of this analysis are shown below:

4. 1. Past observation

In port logistics chains, both physical and documentation flows converge, and technological advances make it possible to streamline the processes of this information flow and thus improve the services offered. In this context of the incorporation of technologies in the port environment, a series of phases can be distinguished according to the degree of technological development achieved.

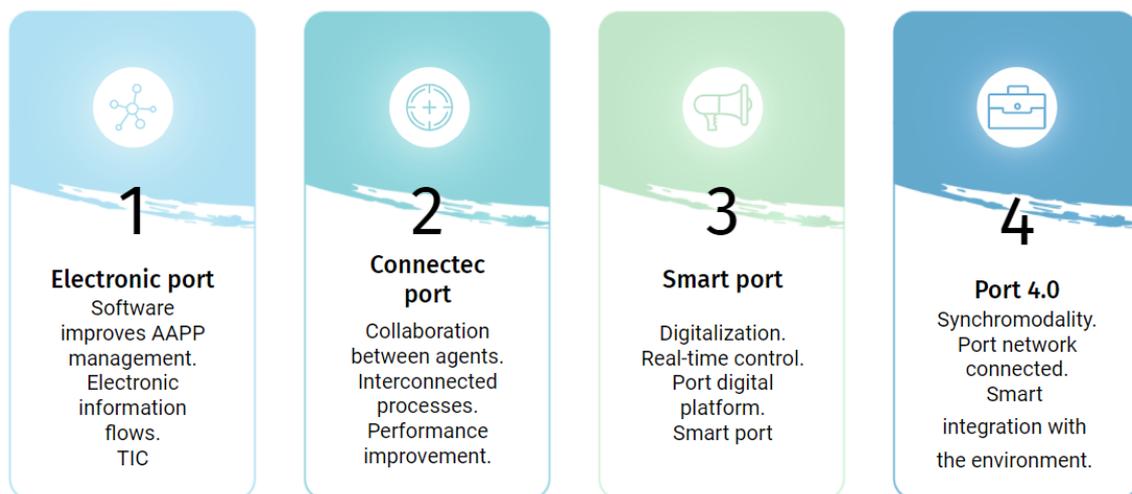


Figure 3. Port technological development. Source: own production based on "El papel de los puertos en la nueva economía 4.0", Puertos del Estado

Firstly, there is the case of electronic ports. Its main innovations were the application of software to improve the management of Port Authorities, the use of electronic information

flows, and the incorporation of ICT in the different processes and operations. An example of this application was the electronic transmission of the Single Administrative Document between customs offices (Figure 3).

After this incipient software application comes the need to establish an efficient connection between the different port actors. This improvement in performance would be made effective through real collaboration between these agents for the provision of data, thus facilitating the interconnection of port processes.

Finally, the concepts of Smart Port and Port 4.0 appear as a consequence of this technological development and the new needs derived from its optimization. The keys to this new operation lie in the widespread application of digitalization and synchronicity to all processes, without forgetting other essential aspects such as security and sustainability.

The smart port concept does not have a single definition; information technology is the basis and digitalization in logistics is the key to success.

4. 2. Present study

4. 2. 1. How?

- The Ports 4.0 capital fund. This is the corporate open innovation model adopted by Puertos del Estado and the Spanish port authorities to attract, support and facilitate the application of talent and entrepreneurship to the Spanish public and private logistics-port sector in the context of the fourth industrial revolution. These are grants on a competitive basis.
- SIMPLE logistics platform. The Ministry of Transport, Mobility and Urban Agenda promotes the development of the SIMPLE logistics platform. It consists of a platform for the exchange of data by telematic means, with the aim of facilitating intermodality in the transport of goods.
- One-stop shop. Platform, based on the single window system developed by Puertos del Estado, which allows the reuse of information throughout the logistics and transport chain.
- Stowage+2022 Programme. The programme seeks to develop Industry 4.0 technologies for the digitalization of Spanish ports using highly automated logistics (smart digital ports).
- Technological development of the Tax Agency. They use telematic means for the dispatch of goods, authorizations for port calls, etc.
- Digital platforms. Port authorities have implemented digital platforms for the electronic transmission of invoices and settlements.

4. 2. 2. Why?

- Reduction of the costs of physical storage of documentation and the use of paper and printouts.
- Protection and better preservation. The paper medium is vulnerable to various external factors that can damage the material.
- Decentralization of information. Increased productivity and fast and secure access to information will be ensured. This access will be through different technological devices.

- Medium to long-term investment. Despite the great financial effort involved, and the digital training of the workforce required, the company will be able to improve its market positioning and open up to new business alternatives.
- Better access and time management when consulting data. Digitized documents can be viewed by a greater number of people with less effort.

4. 2. 3. For what?

- Attracts and retains talent. The digitalization of a company improves its online image and reputation. This is valued not only by customers, but also by professionals in this or related sectors.
- Increases productivity. Digitalization allows all decisions to be made and executed faster.

4. 3. 4. Who?

- New profiles. New professional profiles will be generated and it will be necessary to adapt existing ones to the use of technology. The need to implement different training plans to provide port employees with new competences and skills has already arisen in the port authorities.
- Lack of training. The lack of training of the port community anchored in old processes and procedures, which have nothing to do with the new technologies, together with the high cost of implementation, can be a challenge in the short and medium term for certain links in the chain.
- Non-face-to-face working. The convenience of being able to work from home, the possibility of being able to work anywhere and at any time.
- New working methodologies. A working methodology will have to be implemented to obtain new talent and ideas, manage new initiatives, ensure the shift from innovation to operation, and measure and assess each step of this process.

4. 3. 5. Macro environment

4. 3. 5. 1. Economic environment

- High financial resources... The need to provide high financial resources is a stumbling block that many companies in these communities cannot afford.
- State funding. From a political point of view, and given that fleet modernization is necessary and many shipping companies are hesitant to invest in new technologies due to high investment costs, some funding should be made available at state level to compensate for such investments.
- State finances. Available cash flows are being constrained by the financial situation, lack of credit and regulations on financial institutions to reduce risk exposure by creating stronger deposit bases. This slows down investments in port digitalization actions.

4. 3. 5. 2 Institutional environment

- Policy aspects. The policy context is important for understanding smart ports initiatives, which comprise both policy and institutional elements. The transformation towards digitalization of ports requires the interface of technological elements with policy and institutional elements.
- Port communities. The interconnection between the digital platforms of the entire logistics chain and the collaborative economy itself, both stemming from digitalization and ports 4.0, may necessitate the development of changes or modifications to the state port governance model itself. In the new digitalization model of the port industry, it will be the port communities themselves (not only the port authorities independently) that will jointly and collaboratively develop those strategies to adapt this new digital model to their own reality in order to improve the competitiveness of the global port service, supported by the aforementioned technological innovation.

4. 3. 5. 3. Social and cultural environment

- Port-city synergy. The digitalization of ports in relation to the development of smart cities enables a synergistic interaction between both institutions, their governors and their citizens. Digital ports are by and for people; therefore, it is the key agent in their future development.
- Socio-cultural factors. Full automation will only be achieved through communication and dialogue with trade unions, who are involved in the project and provide the necessary information and training.
- Cultural change. The keys to maximum efficiency through digitalization will be underpinned by a cultural change, which implies a new vision of the port sector, especially with regard to innovation.

4. 3. 5. 4. Technological environment

- Cargo. The objectives for cargo are as follows: * Improve the management and traceability of maritime cargo through end-to-end digitalization of the supply chain. Process integrations based on these new information technologies can simplify all these procedures and improve coordination and security, in a highly collaborative environment between the different agents.
- Short-term vision. From a technological point of view, and given that many companies are not yet aware of this, it would be necessary to make more appropriate investments in the security of information systems, increase security and data protection in the sector to avoid manipulation of sensitive systems and implement measures to protect data against unauthorized access and any type of abuse (by cloud-based user systems, access management, device management and data backup).
- Solutions. It is essential that this process is reflected in the strategic plan of each Port Authority. To meet this new challenge, there are port authorities that have opted to contract something ready-made (with specialized consultancies that sell you almost the complete package of a smart port). This is something tested, although less flexible, which allows them to start taking steps almost immediately in this transformation. The

other option is to use tools with ad hoc solutions. Developing "tailor-made" applications usually fits better with the organization. However, they have a higher maintenance cost and lack of integration with other systems on the market.

- Tools. To achieve this, the following tools are available: Internet of things, Operations automation, Blockchain, Artificial intelligence. Big data: big data and IoT, RFID.

4. 3. 5. 5. Legal environment

- Legal disparity and scope of application. Inconsistency in national and regional policy-related rules and regulations cannot help to scale up smart city initiatives.
- Data registration. The legal point of view is the aspect that would need the most work to shape, as the use of AIS and RFID technologies require automated registration of personal data in some applications.
- Security and integrity of the enterprise. These are essential to realize the transformation to the 4.0 concept. The digitalization of ports makes it possible to adopt systems that increase efficiency and transparency for the various actors involved, while eliminating the need for paper documents and increasing overall security.
- Security and technology. Digitalization at port level increases the security of the different terminals, as artificial intelligence (AI) provides better control over who enters and leaves the port.
- Cybersecurity. The digitalization of our new world, and the development and progress of technologies, means that we are much more vulnerable and sensitive to attacks through cyberspace. Unfortunately, these systems are also very vulnerable to cyber threats.

4. 3. 5. 6. Sustainability environment

- Control and optimization of energy, water and waste resources through new technologies add environmental value not only to port management, but to the entire logistics chain. This makes it possible to meet sustainability objectives, which nowadays are indispensable for society.
- More sustainable port. Improving environmental quality and, therefore, the quality of life not only of people, but also of the environment.
- Efficient and predictive supply chain. More sustainable management is needed to reduce pollution and gain flexibility and agility.

4. 3. 6. Micro environment

- Customers: port-city relationship and relationship with shipping lines
- Competitors: study of the main competitors in Spain
- Products: new substitutes
- Suppliers: negotiation at European and Spanish level and the applied negotiation model
- Rivalry: new entrants

4. 4. Future planning

In the old days, seaports functioned as the owners of the global shipping and logistics industry, as well as the companies that depended on the fast and efficient transport of goods.

However, as global trade transforms, the role of seaports is also changing.

The coronavirus pandemic is expected to accelerate the digital transformation of the global seaport community, changing the role of seaports from passive owners to a driving force in the ongoing digitalization of the maritime industry.

The port community is slowly embracing new digital technologies; digitalization will drive down costs by optimizing port operations, make ports greener and open up new business opportunities. Those who do not digitize now may well lose customers to those who are willing and able to turn a crisis into a springboard to the digitized future of the maritime industry.

Hopefully, some good will come out of the current economic crisis, as the demand for cost-effective operations will spread throughout the supply chain, thus forcing ports to accelerate this digital transformation.

Automation is being adapted by all industries. And while the maritime port sector has joined the trend, it seems that there is still a long way to go.

Normally, the port and the city have coexisted independently of each other. The port can even be seen as a nuisance to the city, rather than an opportunity to generate economic growth.

Consequently, one of the first things to do is to achieve a holistic approach to city + port integration. This requires the use of the latest technologies at the service of customers.

Not only that, it also requires process optimization, sustainability, as well as full integration with the city. In this way the port and the city will work together and not separately.

In this perspective of sustainable ports, ports should contribute to the city and not, on the contrary, consume its resources. Hence the importance for the ports to have a dedicated renewable energy source.

Finally, in order to have more intelligent and sustainable ports, it is necessary to be environmentally aware. In this case, the aim must be to reduce port call times or to reduce polluting emissions, among others.

5. CONCLUSIONS

In this diagnostic study, which aims to take a snapshot of the current situation in order to be able to undertake planning, it is concluded from the use of the End to End Tool that Spanish ports are currently in a medium-low position in terms of digitalization, and continue to update and innovate in order to be increasingly competitive in the market.

Despite this, there is still a long way to go in digitalization, such as the immediate conversion to digital, intelligent and green ports, which optimize existing infrastructures with added capacity thanks to the intelligent management of spaces.

This requires the integration of technologies such as the cloud, big data and sensorization, as mentioned above. In this way, and working together with the port community, ports must promote the creation of more efficient logistics platforms, so that we can advance in the level of maturity of the Spanish port system. To this end, they must encourage coordination and communication between the different actors in the port-logistics field. However, the mere existence of this technological offer does not in itself guarantee that a community is "smarter".

The experience of various port communities, both nationally and internationally, shows that the result or impact produced by the introduction of these technological changes is not homogeneous.

Technology matters, and matters a lot, but the determining factor in the success stories is smart governance. From the analysis proposed through the End to End Tool, it has been possible to conclude that the indicators on which it is necessary to focus in order to define a strategic plan and future lines of action are, firstly, data: a clear message is that sharing data strengthens processes, reduces waste and makes port operations more efficient.

While it is clear that digitalization can lead to greater efficiency, help reduce costs and provide numerous environmental benefits, ports and the maritime industry in general have been slower to adopt digitalization than other industries: the main problem facing the Spanish port sector is the fear of creating a competitive disadvantage if data is shared. Secondly, it would be necessary to move towards a new port community paradigm, so that the flow of information between the participants of a port community is done in a reliable, efficient, paperless way, and thanks to technologies such as blockchain it is also done in a secure way. The third important element to advance in the process is the development of new profiles. This commitment to technology is not only changing the way of working and doing things in port facilities, but also the profiles of the workers themselves, who see how the competences related to digitalization are becoming more important in order to be able to perform their tasks properly. Thus, digital knowledge and information management, understood as the ability to develop professionally by efficiently using digital resources and tools and integrating all of this into their day-to-day work, is fundamental in this environment.

Once again, it is clear that technology alone is of no use in achieving smart ports 4.0. It also needs to be used in an integrated, open and joint manner by all the agents of the port community. Unlike the traditional model based on a government (port authority) defining the environment for the activities carried out by all port operators, smart governance should be characterized by the elements in Figure 4.

The Revolution 4.0 in each of the elements that make up the port dimension will be based on:

- Nautical operations: In these, the automation of the instruments involved in these operations is pursued.
- Hinterland and Logistics: The focus here is on synchronomodality. This new concept requires the formation of information exchange platforms in order to optimize routes and delivery times.
- Infrastructure and energy: This applies to the concepts of maintenance, environment, and safety and security.
- Governance: Management, relationship, and employment models have also been modified by the implementation of smart technologies.
- Digitalization: Digitalization is arguably the main means for the 4.0 transformation in ports. Rapid access to information: fast and accurate identification of vehicle and container registration using RFID (Radio Frequency) technology. This can include data about container shipment, and supports dynamic management of throughput, and port entries and exits.
- Synchronomodality, or synchronized intermodality, allows decisions on transport mode and routing of each element of the system to be made as late as possible in the transport planning process and the journey itself.



Figure 4. Characteristics of smart governance

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