



# Conceptualisation of the Port of the Future based on the Business Canvas Model: Case study of the Vision 2040 for Barcelona

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## ARTICLE INFO

### Keywords:

Ports of the future  
Maritime and port trends  
Port strategy  
Future port business models  
Business canvas model

## ABSTRACT

The revolution towards the port of the future is going to change the long-term Port Business Ecosystem (PBE). The objective of this paper is to analyse how current trends might have implications for the future PBE. For this purpose, the research uses the Business Canvas Model (BCM) as a framework tool. The BCM models are based on data from a literature review of trends, interviews and workshops with relevant port stakeholders that validate the results. A specific case study is done for the Port of Barcelona. Some of the conclusions are suggested to be extended to other EU Ports. The results of this research are conceptual actions to be considered and introduced in port planning to ensure its sustainable growth in harmony with its nearby societies. Results suggest three main policy recommendations to foster new future business models for ports: 1) develop sustainable green energy hub models (energy communities, hydrogen strategies, etc.), 2) develop intermodal logistic hubs not only oriented to the maritime sector and 3) promotion of emerging industries to become a customization hub adding logistic value to the cargo transiting the port. All these recommendations are highlighted in order to define key drivers of a generic European port strategy masterplan.

## 1. Introduction

The evolution of ports is related to their economic, social and environmental ecosystem, which is constantly changing. Relevant trends and disruptive technologies will transform the role of ports in the next decades. Port authorities around the world are modifying the nature of ports and their role, acquiring a more and more active role in the governance of logistic systems and often adopting a managerial and entrepreneurial approach (Cepolina and Ghiara, 2013).

Up until 1999, four seaport generations succeeded one another. The 1st generation includes the ports developed prior to 1960, which were focused on semi-bulk cargo. The strategy of these ports was quite conservative, having a simple role as communication nodes between maritime and land transport. Their main added value was the loading and unloading, storage and navigation services.

From 1960 to 1980, the 2nd generation of ports was developed, based on a redefinition of their role and strategy, in part due to the technological revolution of the container and the growth of ship sizes. Ports focused towards expansion, transport, industrial activity, and became important commercial nodes.

From 1980 to 1999, the 3rd generation was launched, with the transformation of ports into a logistic distribution center for international trade. Those ports offered other value-added services such as warehousing, packaging and distribution, providing additional employment and revenue to the port community. (UNCTAD, 1992).

In 1999, the UNCTAD defined the 4th fourth-generation port, which is physically separated but linked through common operators or a common administration. The added value of this new port is focused on the quality of port services, IT usage, the development of a port community, the existence of the port logistic center, and among others, the quality of connections with the hinterland on the land side and the foreland on the seaside (UNCTAD, 1999).

The “Ports of the Future”, also known in the current literature as Port 4.0 (Brümmerstedt et al., 2017) or Port 5.0 (Flynn et al. 2011, Kaliszewski, 2018) are the next generation of ports. According to the authors, they will have to adapt their business models in order to keep creating value to their nearby society ecosystem which is constantly intensifying its level of digitization. As a result, the evolution of ports has forced relevant transformations in port management and this trend is expected to continue in the coming decades.

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<https://doi.org/10.1016/j.cstp.2022.05.002>

Received 10 June 2021; Received in revised form 13 April 2022; Accepted 5 May 2022

Available online 10 May 2022

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The objective of this paper is to determine how the most recent relevant trends will impact on the evolution of ports and business ecosystems. General technological or context trends impacting on the PBE have been identified in this research. They have been divided into 5 categories: Energy and environment, macroeconomics and geopolitics, society and consumption patterns, logistics chain and maritime and port sector. The analysis of how these trends affect the ports are conducted by means of the Business Canvas Model (BCM), comparing two different timeframes: 2020 and 2040. The BCM was developed by Alexander Osterwalder in 2008, and it is used in this research to conceptualize the future of PBE, providing key strategic conceptual actions for port managers.

The first section of this paper is focused on identifying state-of-the-art research related to the analysis of the evolution of the port business ecosystems. The second part describes the methodology used in the current research, explaining in detail the Business Canvas Model applied to ports, which is the framework tool to conceptualise the port of the future. The third part of this study includes: the results of the current BCM for the Port of Barcelona (2020); the identification of current trends impacting on PBE; and, finally, the BCM expected for 2040. To conclude, general conclusions and policy recommendations are given, the BCM of 2040 is put in a general context, giving the opportunity to extend it to other European ports.

## 2. State of the art

Several authors have done research on the evolution of the role of ports, their management and value creation, usually considering the different activity sectors. Some recent and relevant literature related to this topic is presented hereunder.

Current literature defines the concept of the Port Business Ecosystem as a sort of economic association that is formed by ports and related associations (Li et al. 2020), including port enterprises, shipping companies, shippers, freight forwarders, governmental public authorities, etc.

The evolution of society and technology has forced the port authorities to take on a new role as community or cluster manager (De Langen, 2004). In most ports, an autonomous but government-owned port development company is responsible for port development. This company aims primarily at financial sustainability and creating broader societal value. The central concept in assessing the role and business model of the port development company is the concept of the port as a 'business ecosystem' (Van der Lugt and de Langen, 2018).

Ports are facing new challenges related to the sustainability of business models from economic, environmental and social points of view (Perboli et al., 2017; Nicolas et al., 2016). Stakeholders, including companies operating in the transportation industry and local administrations, have a strong interest in new solutions and business models that would make logistic activities more sustainable in terms of economic efficiency and environmental impact. Ports, being an important node in the logistics supply chain, need to have an active and important role in bringing about a more sustainable industry.

According to Martín-Alcalde et al. (2016), in the last decades, globalization has forced ports to become more focused on logistics, which have been integrated in the supply chain offering added value logistic services. Therefore, ports are working and intensifying efforts to become an integral part of a logistical corridor, increasing the complexity of the PBE.

Other authors have studied the development of ports beyond their traditional role, as landlords with a focus on partnerships and collaboration. Krangelum (2019) concludes that the way in which ports create value needs to be rethought. This might require new managerial logics and practices, in addition to engaging in partnerships to co-create value with stakeholders in the port.

In current literature, researchers have also analyzed how the circularity transition affects the role and business model of port authorities as developers of port clusters (de Langen et al., 2020). For example, the development of Circular Economy activities occupies a central place in

the Port Authority strategy, and it assumes new and active roles in advancing the circular business ecosystem, most notably through developing industrial ecology synergies and nurturing and attracting new and innovative circular economy companies. Therefore, Circular Economy is a clear example of a trend impacting the PBE of the future.

Information and Communication Technologies (ICT) and the subsequent digitalization and massive information sharing is having a tremendous impact on the PBE. In fact, ports are not just there to function as a node in the network, they are also solution providers for creating fully transparent and real-time visible transfers of their cargo, using sophisticated ICT as well as personal relationships at the same time (Jansen, 2018). Related to ICT, the Physical Internet (PI) will impact radically on the global freight transport and logistics system (Fahim et al., 2021). For this reason, ports are defining strategic path scenarios to reach the PI goals in 2040.

In the current literature, different methodologies and tools have been used to explore the future of ports. Among others, multicriteria and trend analysis (Garrido Salsas et al., 2021), Delphi Method (Fahim et al., 2021) or SWOT analysis (González-Cancelas et al., 2020). However, these methodologies do not deliver holistic results in terms of defining the main global value propositions for a port. For this reason, in this research, we use a BCM framework which offers the opportunity to explore a port vision, considering all its different environments. The main strengths of the BCM rely on its capability to show, in an easy and comprehensible way, how the proposed solutions can deal with user needs, and how users can gain benefits from these solutions (Perboli et al., 2017).

Very little literature has been identified in reference to the BCM in ports. Nitsenko et al. (2017) define indicators for sea commercial ports in order to reach sustainable development goals. Their study defines financial and economic indicators related to the different blocks of the BCM. On the other hand, Guido et al. (2017) have developed research using the BCM and the Value Proposition Canvas (VPC) (Osterwalder and Pigneur, 2014) to analyze synchro-modal solutions in ports. Based on surveys, the VPC and the BCM are built for different projects in the field of supply chain optimization and slow steaming. This approach illustrates the high operational value of knowing stakeholders' requirements in order to develop a solution that meets their needs.

Finally, Krangelum (2019) has developed a review of future challenges for port authority business model innovation with the BCM. This research takes into consideration different levels of analysis, making a distinction between the macro-port industry, meso-port system and micro-port authority business models. The business model challenges identified in this research are: a) diversification of port customers, b) requirements for new value creation, c) changing possibilities and constraints of value capture and d) network effects, clusters and strategic partnerships.

This research contributes to the state of the art, defining a novel methodology to apply the BCM to ports, including trend impact analysis to conceptualize "Ports of the Future". A specific case study for Barcelona is developed to provide an example of application of this methodology. Based on the results, discussions are presented to extend the identified Port Vision to other EU ports.

The BCM can be applied in many PBE worldwide but due to the capabilities and knowledge of the environment from the authors, Barcelona was selected as a case study. The Port of Barcelona (PoB) is a relevant case study to apply the BCM, due to the fact that it is the 11th port in terms of traffic in Europe (see Fig. 3), excluding Turkish ports. Additionally, it is a very diversified port in terms of sectors (logistics, industrial, leisure, etc.) and covers diverse traffic (containers, Ro-ro, liquid and solid bulk, Ro-pax, cruises, etc.). It has important hinterland connections with Spain, Andorra, and southern France as well as regular foreland maritime connections with all the continents. The PoB has a large and innovative Logistic Activity Zone, as well as a Port City waterfront since the Olympic Games of 1992. To conclude, it is quite unique because it is several types of ports in one, providing therefore a complete case study to apply the BCM in ports.

### 3. Methodological approach

The methodology developed in this research is illustrated in Fig. 1. It starts with a preliminary desk research to select the ideal tool to conceptualize the port of the future. Based on the current state of the art, the BCM is selected. Then, the research is based on 4 subsequent phases: 1) Conceptualisation of the BCM 2020, used as the baseline scenario; 2)

Analysis of trends that will affect EU ports in the future; 3) Based on the current BCM and the future trends identified, a BCM 2040 is built to conceptualize the “Port of the Future”; 4) Analysis for the replicability of the results to other EU ports.

As illustrated in Fig. 1, it is important to note that the selection of trends impacting on the PoB is based on previous research conducted by the authors. In this research, emerging trends defining the future role of

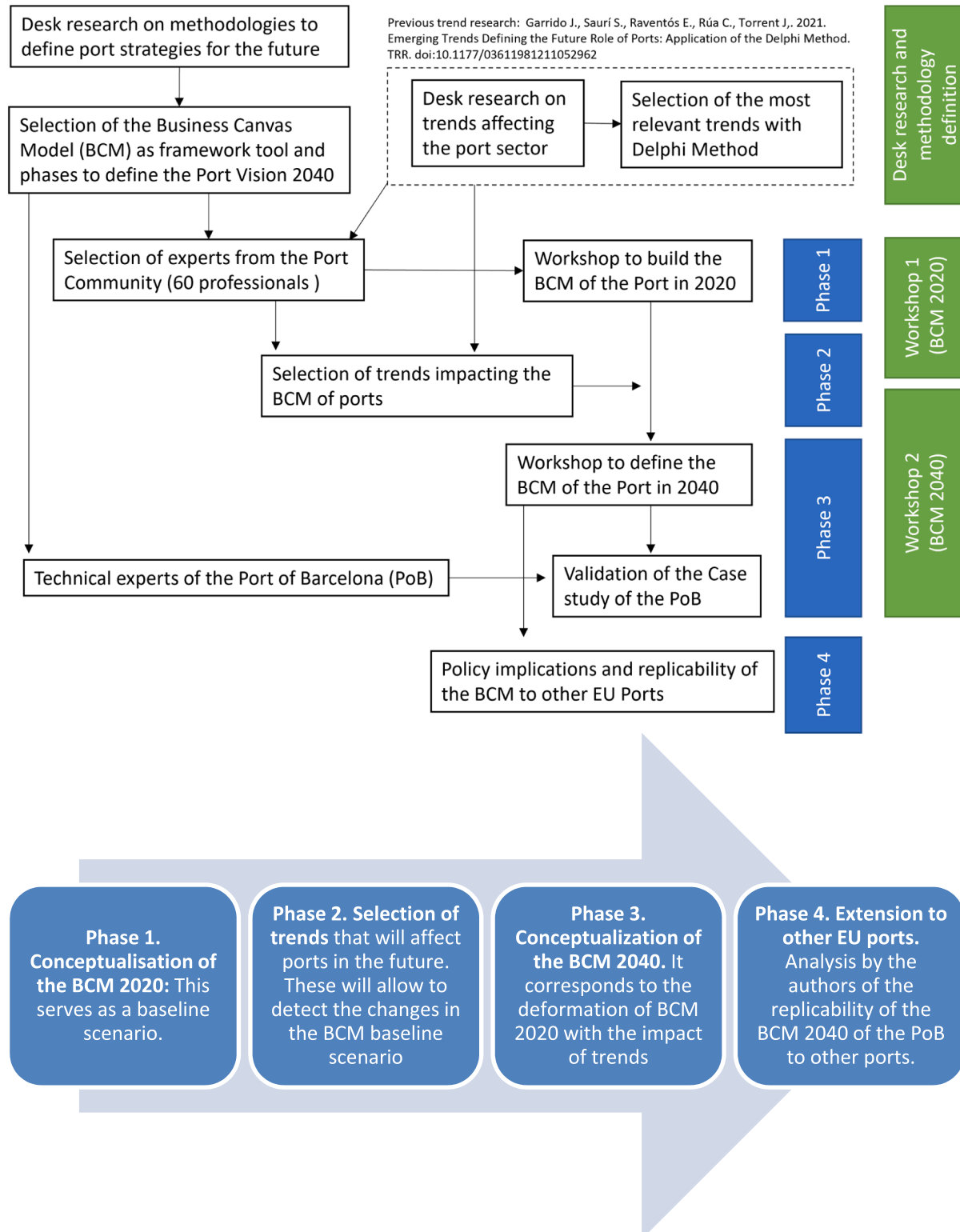


Fig. 1. The proposed methodology to define the BCM of a port is divided into four phases.

ports were identified by application of the Delphi method.

### 3.1. The case study of the port of Barcelona

In order to capture the data and input to construct the BCM of the PoB, two workshops have been organized with the Port Community experts who worked on the IV Strategic Master Plan of the PoB. Among the experts we selected there are: national and international consultants (8); port authority employees (11); managers of port concessions (15); university academics (6); technical engineers of the city council and government (4); and finally, a representative sample of logistics managers (16) of some companies of the hinterland. The experts selected for this research are a sample of the participants in the research of trends (Garrido Salsas et al., 2021).

Due to the COVID-19, the first workshop was done partly online. Virtual participation consisted of more than 40 experts and on-site was made up of 20 experts of the Port Community. In this workshop, the current BCM 2020 of the PoB was presented and discussed based on desk research and the expertise of authors. Then, a set of trends (see section 4.2) impacting the future of ports was discussed. To conclude the workshop, a draft of the BCM 2040 was done with the port community stakeholders, to define the scope necessary in order to hold the 2nd workshop with the port managers.

The second workshop was held with the key experts of the main areas and departments of the Port Authority of Barcelona: strategy, innovation, commercial, financial, human resources, environment, communication and technology systems and infrastructures. The aim of this second workshop was to have validation of the results obtained in the first phases of this study and establish the definition of the definitive BCM 2040.

Finally, this case study of the PoB is analysed and relevant conclusions for other European Ports are extracted, based on the authors' and the Port Authority professionals' discussions. The conclusions of the paper help to define some recommendations to develop further transport policies, identifying some implications of the trends for the business models of other EU ports.

### 3.2. The business Canvas model applied to ports

In this paper the BCM is the tool used to conceptualize the port of the future. Osterwalder (2010) developed the BCM, a strategic tool to develop new business models, or document existing business models. It consists of a visual and pragmatic table with elements that describe a company and its products (value propositions), infrastructure, clients and finances. In particular, it has 9 blocks that are described in Fig. 2.

In this research, the BCM is applied to the Port Business Ecosystem. For each of the blocks, the key questions to answer taking into consideration all the PBE are defined below. These questions are formulated by the author, adapted to the PBE, cited as ports. They have been adapted based on the questions from the nine-business model building blocks defined by Osterwalder et al. 2010:

1. Value proposition: What value does the port deliver to customers? Which of the customer's problems are ports solving? What bundles of products and services are the ports offering to each Customer Segment? What customer needs are ports satisfying?
2. Customers segments: Who are ports creating value for? Who are the most important customers? What types of customers are there? What type of relationship does each of the ports' Customer Segments expect to establish and maintain?
3. Channels: Through which channels do ports' customer segments want to be reached? How are ports reaching them now? How are ports' channels integrated? Which ones work best? Which ones are most cost-efficient? How are ports integrating them with customer routines?
4. Customer relationships: What type of relationship does each of the customer segments expect to establish and maintain? Which ones have ports established? How are they integrated with the rest of the port business model?
5. Revenues: What value are ports' customers really willing to pay for? What do they currently pay? How are they currently paying? How

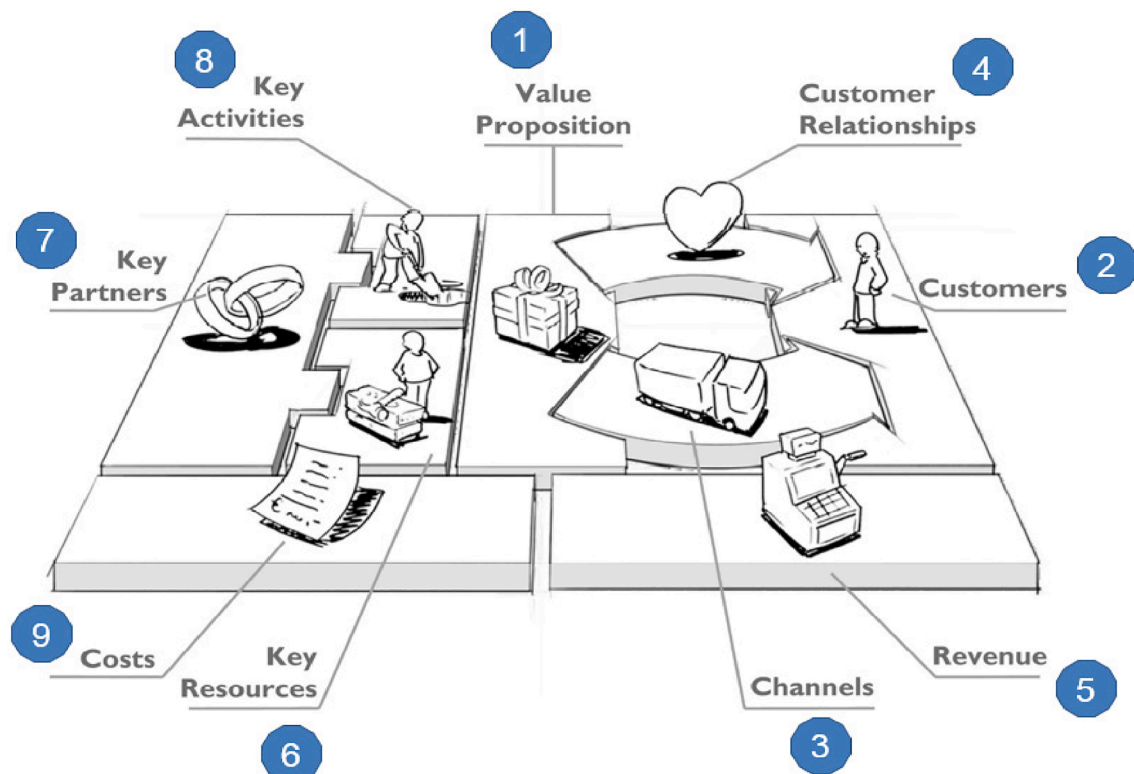


Fig. 2. Models and relationships of the Business Canvas Models. Source: Strategyzer.

would they prefer to pay? How much does each Revenue Stream contribute to overall revenues?

6. Key sources: What key resources do ports' value propositions require? And ports' distribution channels?

7. Key partners: Who are ports' key partners? Who are ports' key suppliers? Which key resources are ports acquiring from partners? Which key activities do partners perform?

8. Key activities: What key activities do ports' value propositions require? Which are the ports' distribution channels?

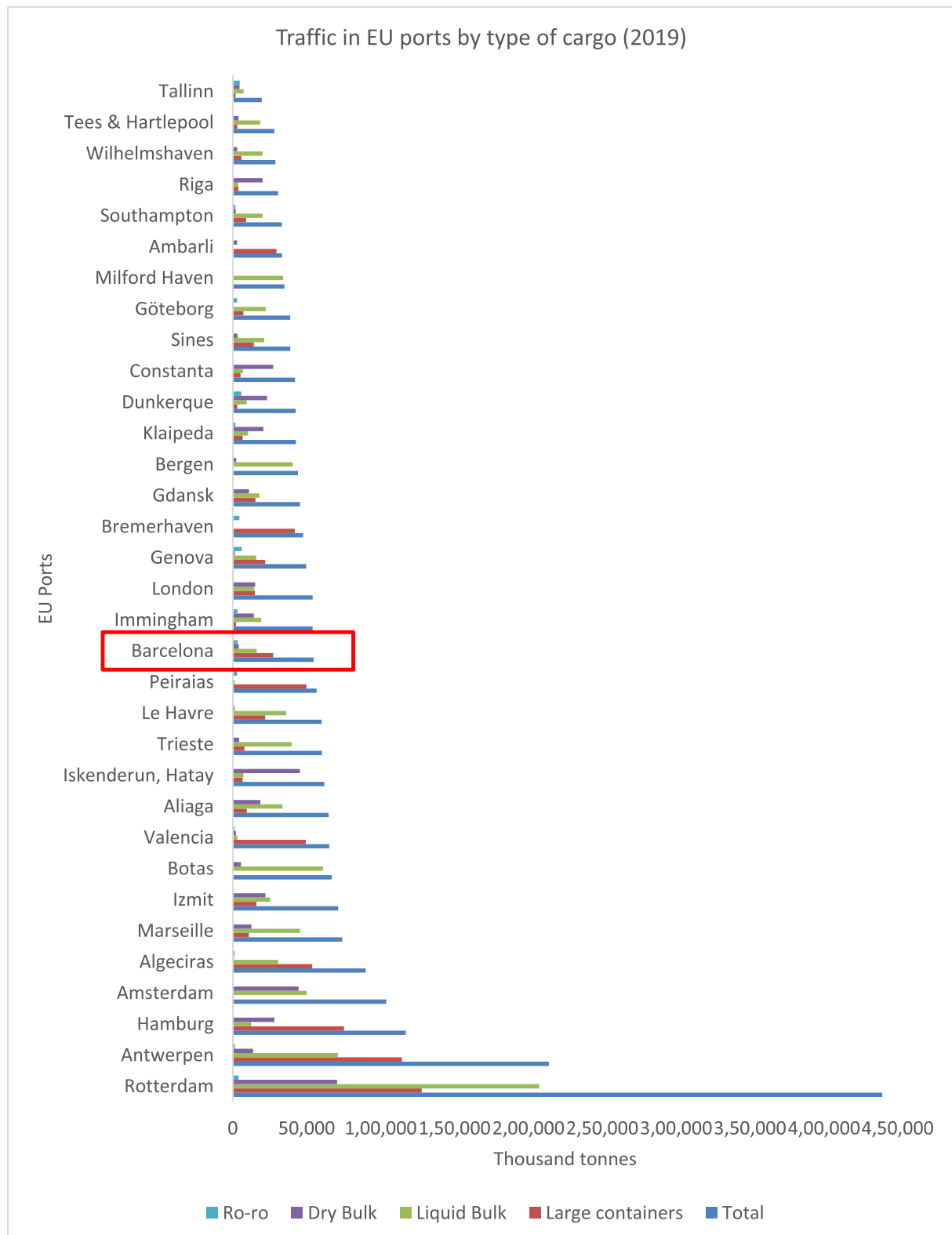


Fig. 3. Comparison between the trades in EU Ports based on the type of cargo. Own source based on 2019 data from Eurostat.



9. Costs: What are the most significant costs inherent in ports' business model? Which key resources are most expensive? Which key activities are most expensive?

#### 4. Case study: Business canvas model for the port of barcelona in 2040

This section will analyse the PoB as a PBE and identify the impact of the different future trends on it. The PoB is an interesting case study of a Mediterranean Port due to the fact that is very diversified and holds an important trade influence in the south of Europe. As can be shown in Fig. 3, the PoB is a diversified and representative port with different types of cargo and very close to the average of a European Port which is 23.679 thousand tonnes of large containers, 27.290 of liquid bulk, 12.909 of dry bulk and 1.597 of Ro-ro. Additionally, for container traffic it has a good balance between transshipment (40%) and import/export (60%) based on 2019 data.

Firstly, it is important to introduce the main characteristics of this port. The PoB belongs to the Spanish Ports Authority (Ministry of Transport). The Port Authority of Barcelona functions as a landlord and leases its land to privately owned operating companies (Van Der Lugt and De Langen, 2011). The Port authority, while remaining a government body, has been an autonomous port since 1978, and is able to function as a commercial enterprise subject to private law. The Law on State Ports and the Merchant Navy, published in the Official State Gazette (BOE) on 20 October 2011, is the essential text under the Spanish legal system, which regulates its activity.

Its area of influence stretches through the south and centre of Europe and North Africa. It is a logistics gateway that links markets as distant as the Far East and Latin and North America. The Port has 1,125 ha of land area in the municipalities of Barcelona and El Prat de Llobregat and

includes such elements as 23.2 km of wharves and moorings and 47 km of railway lines (Port of Barcelona, 2021).

The Port is highly diversified, with over 30 terminals able to transport all kinds of products. The main traffic comprises containerised cargo and high-value goods. Barcelona is the leading cruise port in Europe and the Mediterranean. It is the first Mediterranean port for new automobiles and the third largest container port in Spain.

It is a port whose continued increase in goods and passengers has placed it in a leading position in several segments of traffic among the Mediterranean ports. With traffic in 2019 of 66 million tonnes, 3,3 million containers, 770 thousand new vehicles and 4,6 million passengers, of which 3,1 million were cruise passengers, the PoB is one of the leaders in the Mediterranean and Southern Europe (Port of Barcelona, 2021).

The port is a space of interaction of the more than 500 companies comprising the Logistics-Port Community, where about 37,000 people work daily and which has a direct, indirect and induced impact on more than a quarter of a million jobs. (Port of Barcelona, 2021).

The PoB can essentially be defined in two main ways: a platform for the interaction between demand (international foreign trade mainly by sea) and logistics operators and an intermodal node of international trade in southern Europe. According to data from 2019, the Port channels €65 billion of foreign trade (including coastal shipping and excluding transshipment) and generates €11.553 billion and 7.1% of Catalonia's Gross Value Added (Port of Barcelona, 2021).

##### 4.1. BCM of the port of Barcelona in 2021

The following Table 1 is the BCM of the PoB. It has been developed by the authors based on desk research and validated in a workshop held in Barcelona with experts of the Port Community.

**Table 1**  
Business Canvas Model of the Port of Barcelona in 2020. Source: Authors.

7. KEY PARTNERS	8. KEY ACTIVITIES	1. VALUE PROPOSITIONS	4. CUSTOMER RELATIONSHIPS	2. CUSTOMER SEGMENTS
Logistic operators Hauliers Freight forwarders Shippers Shipowners Customs Intermodal terminals Government institutions Cities Specialized Logistic Areas Free economic zones	Loading/unloading of goods (freight and passengers) Maritime and land transport Nautical and Leisure Ship repair and maintenance Advanced logistic services Port services Custom services	Traffic specialization (container, solid or liquid bulk, ro-ro, cruises, vehicles etc.) Diversification of activities National or international distributor Logistic infrastructures Geographical location Hinterland potential Good hinterland connectivity Transshipment Ship build and repair services Touristic services Ferris services Leisure and nautical services	Focused on large customers Promotion of the port area to attract investors	Waterborne logistics companies: shipping lines, liners and carriers, freight forwarders and shippers Hauliers Logistic and terminals operators Commercial and industrial firms Large import/export distributors Multinational and global companies Manufacturing companies Passengers and tourists
<b>6. KEY RESOURCES</b> Land and sheltered waters Infrastructures Human capital Digital infrastructures Port Community system Port network including intermodal terminals in the hinterland Financial resources		<b>3. CHANNELS</b> Commercial actions Mechanisms of interaction with traditional customers Inland Terminals Training		
<b>9. COST STRUCTURE</b> Human resources Digital infrastructure Infrastructure maintenance Energy Financial Security and cybersecurity		<b>5. REVENUE STREAMS</b> Traffic of passengers Traffic of goods Tourism, nautical and leisure activities Logistic added services Land concessions		

**Table 2**

Future trends with high, medium and low impact on the BCM 2040 for the PoB. Source: Own formulation based on the IV Strategic Plan (2021–2025) of the PoB (Port of Barcelona, 2021) and (Garrido Salsas et al., 2021).

		Impact on the 9 building blocks of the BCM 2040 (numbers according to Fig. 2)		
		High	Medium	Low
<b>Environment and energy</b>	Climate change	1,6,7,9	2,8	4
	More sustainable energy mix	1,6,7,8	2	9
	Increased electric mobility	1,6,7,8	5	2
<b>Society and consumption</b>	Servitization of the economy	1,3,4	2,6	9
	Increased tourism	7,8	5	2
<b>Macroeconomics and geopolitics</b>	Slow growth/stagnation of western economies	2,7	3	5
	Consolidation of the Far East as a global economic and political centre	3,7	2,5	5
	Strong growth in emerging markets: Africa/Southeast Asia/India	2,7	3	5
	Urbanization and world population growth (except: EU, Japan, China)	2,4,7	1,5	9
	Growth of Blue Economy	1,2	5,7,8	9
<b>Logistics chain</b>	Digitalization of supply chains	1,2,3,4,5,6,8	9	7
	Growth of e-commerce	1,2,3,4,5,6,8	9	7
	Additive manufacturing with 3D printing technology	1,7,8	2,5	9
	Increase in the autonomous transport of goods	1,6,9	2,7	4
<b>Maritime and port sector</b>	Moderate increase in ship size	6,9	2	1
	Concentration of operators and shipping companies	2,3,4	7	5
	New transport routes	5,7	2	9
	Digitalization of processes and operations	1,2,3,4,5,6,8	9	7
	More sustainable ship fuel mix	1,6,7,8	2	9
	Increased awareness by stakeholders and public of port activity effects	2,7,8	1	4

#### 4.2. Trends affecting the port of Barcelona in the next decades

Taking a long-term vision, this section sets out the main trends in the various areas that can affect the future evolution of the port and assesses their potential impact on Barcelona's port and planning activity. This set of trends is based on the previous research of the authors "Emerging Trends Defining the Future Role of Ports: Application of the Delphi Method" (Garrido Salsas et al., 2021). Table 2 reflects on the trends and the impact (high, medium and low) on the BCM 2040 of the Port of Barcelona (Table 3).

In order to identify the main trends affecting ports, Garrido Salsas et al. (2021) used the Delphi Method combined with desk research. It is important to note that the port community experts working on the BCM research were also working on the previous research to identify the trends in the port sector and analysing the impact on the PoB. According to the authors and port professional experts, the global trends with a potentially higher impact on the BCM evolution of the logistics-port sector are as follows:

- A growing environmental awareness on the part of society that translates into accelerated steps towards energy transition (on shore power supply, renewable energy production, circular economy, etc.).
- An increasing maturity of some disruptive technologies in production processes (3D, robotization, automation, etc.).
- New mobility schemes (autonomy, shared use, technology, electric mobility) would force ports to adapt their infrastructures.
- More logistic activities in ports would lead to new models of Port Centric Logistics.
- New trade routes would increase/decrease trade flows in some ports.
- Ship size and capacity would make infrastructure investments necessary.
- An unstable world, geopolitics linked to globalization and the growing political, social, cultural and economic interconnection.
- The huge growth of some emerging economies that contrasts with the aging and weakening of more mature ones, such as the European one.
- Globalization with greater frequency of disruptive events (i.e., viruses, cyberattacks, environmental catastrophes, fake news, physical and digital wars, etc.).
- A change in the patterns and models of consumption, work, production and supply chain linked to the hyper-digitization of society.

There would be a need to improve the efficiency of the process of loading/unloading of goods through digitalization.

Essentially, these trends indicate a similar evolution to that of industry, especially the technological ones. The trend would be for ports 4.0 to become consolidated as the industry 4.0. The evolution of industry in the four phases mentioned previously is complex and hasn't always followed a linear progression. For this reason, the comparison between the evolution of industry and ports isn't completely straightforward. However, there are certain key elements that are comparable between the two.

In the first phase of evolution, ports became mechanized with basic cranes. This period lasted until the middle of the past century. In the next phase, the spreading of mass production systems was parallel to the development in ports of an increased capacity for cargo and augmented traffic volumes. In 2019, the world levels of loading and unloading cargo had tripled since 1980 (UNCTAD, 2021).

In recent decades the operations of ports have become automatized and digitized. This has been especially noticeable in the container terminals sector. Finally, this trend of improved logistics and digitization would lead to the industry 4.0 and ports 4.0. This last phase is characterized by an overall improvement in the efficiency of operations, with a special focus on sustainability and *Smart* processes.

#### 4.3. BCM of the port of Barcelona in 2040

Based on the BCM of the PoB in 2020 and the future trends discussed in the previous section, the expected BCM of the port of the future is presented in Table 3. It has been done based on the baseline scenario and by analysing the inference of the trends of section 4.2. Therefore, the result is the deformation of the current BCM 2020 with the impact of the trends. This conceptual exercise was executed during the workshops held with the port community. The authors have also made some assumptions based on the desk research and their experience in the port sector strategy.

In the BCM of 2040, some particular aspects are highlighted in bold, which the authors and port experts consider are applicable for Barcelona but also for other EU ports. These points will be discussed in the next section.

If we analyse the set of changes of how the BCM model will be modified as a result of the main current trends affecting ports in the long

Table 3

Business Canvas Model of the Port of Barcelona in 2040. In bold the aspects that are applicable for Barcelona but also for other EU ports. Source: Authors.

7. KEY PARTNERS	8. KEY ACTIVITIES	1. VALUE PROPOSITIONS	4. CUSTOMER RELATIONSHIPS	2. CUSTOMER SEGMENTS
Logistic partners New Industrial partners (customization, postponement, 3D printing) Ports: alliances and cooperation between ports. <b>Regional and intercontinental alliances.</b> <b>Intercontinental links.</b> <b>Energy partners</b> Partners of electric mobility and other sustainable fuels <b>Innovation and research partners (universities, research centres, etc.)</b> Metropolitan Area or Regional governments Re-industrialization partners Public companies from Asia and Africa Technological partners	<b>Automation of loading/unloading of goods</b> <b>Green Port operations and provision of sustainable fuels</b> Specialization in advanced logistic services (ZAL) Increasing efficiency and services of PCS and Port operations (goods and passengers) <b>Flexible and resilient land use management</b> under uncertain maritime traffic scenarios Synergic activities between cities and Ports <b>Provide digital infrastructure to interact with autonomous vehicles</b> Customization of products	Better reliability and efficiency with port automation <b>Green Hub for intermodality with on shore power supply and charging infrastructure for trucks</b> <b>Availability of sustainable alternative fuels</b> <b>Efficient management of clean energy using smart grids</b> Increase in the added value of logistic activities <b>Real-time track&amp;trace of goods</b> <b>Deeper digitalization of port services and information</b> Efficient intermodal connectivity with the hinterland, foreland and inland terminals Guarantee of <b>cybersecurity</b> Innovative ecosystem with knowledge and training activities <b>Resilient port services</b> (i.e., against climate disruptive events, pandemics, supply chain disruptions like the block of the Suez Canal, etc.) <b>More flexible land use adapted for new activities</b> creating value for the port and the nearby society Land use for manufacturing (3D) / customization of final products (postponement)	Internal clients (operators, port services, etc.): <b>Cooperation and partnerships between port stakeholders</b> ; Efficient communication based on RPA systems; <b>Cooperation for decarbonizing logistic supply chains; Co-promotion of innovative practices</b> External clients (retailers, shippers, society, etc.): <b>Cooperation to reduce green shipping and the port carbon footprint</b> and develop innovative logistic services; Promoting digitalization of port users <b>Client oriented relationships flexible with demand changes</b> <b>Flexible and resilient contracts</b> (i.e. how the non-expected disruptions should be addressed, adapted to ship size requirements and investments, etc.)	New logistic players (Amazon, Alibaba, etc.) New clients from emergent geographical markets (Africa, India, South East Asia, etc.) <b>Automated ships and trucks</b> <b>Renewable energy producers</b> Waste managers related to circular economy activities
	<b>6. KEY RESOURCES</b> Infrastructure capacity depending on ship size <b>Infrastructures for new alternative sustainable fuels</b> <b>IoT Hardware in the infrastructure for autonomous and connected vehicles and ships</b> Digital Infrastructure with 5G communications Human resources with technological profile. <b>Knowledge-based resources</b> Financial capacity for green and digital ports <b>Automated terminals</b> <b>Smart grids to manage energy generation and supply</b>		<b>3. CHANNELS</b> <b>Digital tools (RPAs) and Digital Twins</b> More direct contact with final clients and manufacturers of goods Identify needs and quality of the port services <b>Real-time update information about the port services and the global supply chains</b> More direct access of small clients (cargo owners) to the Port Authority <b>Intercontinental partner ports</b> Increase in transparency	
<b>9. COST STRUCTURE</b> <b>Investments in digitalization</b> and infrastructure for autonomous and connected vehicles and ships <b>Investments in Green measures</b> Reduction of energy costs by introducing renewable energies and improving grid efficiency Investments in infrastructure for ports calls for bigger vessels (berth line, dredging, etc.) that work with new technologies			<b>5. REVENUE STREAMS</b> Incomes from new logistic services (postponement, 3D printing etc.) and new activities in ports New incomes from port clients by introducing more <b>sophisticated and digitalized scheme prices</b> Research for <b>diversified revenue streams</b> Reduction/increase of revenues due to the effects of new trade routes	

term, the following general considerations can be made.

The **Value proposition** of ports would be completely transformed in the next two decades and based on five pillars: a) The green energy hub model, based on production of renewable energy, storage and distribution of sustainable fuels; b) The digital intermodal hub model, offering an increase in advanced logistic activities and offering real-time information; c) New manufacturing activities especially related to 3D printing and customized services integrated into the logistic supply chain; d) Hub of innovation, knowledge and training activities offering new solutions and supporting the transition towards a Port 4.0; e) Resilient and

flexible governance models with customers and partners.

With regard to **key partners**, ports would intensify relations with industrial partners of manufacturing and customization (i.e 3D printing), logistics (postponement activities) and emergent energy activity sectors and economies (Hydrogen, ocean energy, OPS, etc). Thus, the port would be able to improve its function as a green logistics hub, a trend that is not new and that should keep increasing if ports want to be sustainable from an environmental, economic and social perspective. On the other hand, regional and intercontinental partnerships and links with other relevant actors (airports, ports) would be the key to



developing the value proposition of the future.

With regard to **customer relationships**, and especially current port operators, which may in fact be conceived as internal customers, taking into account uncertainties in traffic (both geographically and in typology and intensity) and the evolution of certain, unpredictable technologies, the relationship would have to evolve from a subcontracting relationship, as a service provider (port operator) and a Port Authority that oversees it, to a closer partnership, sharing risks and being involved in the long-term strategy.

The **channels** of communication in the ports of the future would be fully digitalized and would allow small clients, like cargo owners, to be reached more effectively. The ports of the future would offer real-time updated information. The port community operators and stakeholders would be integrated in the global Digital Twin of the Port, improving the efficiency of movement of goods and passengers. All these elements would help the ports of the future to increase their transparency.

Additional **customer segments** would appear in the Ports of 2040. Related to cargo, new logistic players (i.e. Non-Vessel-Operating Common Carrier) would take control of the whole or a large part of the supply chain. Also, given their automation, a new relationship would be needed for ships and vehicles passing through the port, with vehicle-to-infrastructure connections. Finally, emerging regional markets would enter world trade flows, affecting different ports depending on their geographical location. New energy players would play an important role in the port ecosystem.

**Key activities** in the canvas model of the port of the future would be the increased automatization and the supply of clean energy when managing the flow of goods and passengers, as well as the supply of clean energy for the different transport modes. In addition, a key activity would be the provision of added value logistic services, this last element being very important for the surrounding economy and human capital of the port region. Manufacturing with 3DP or other technologies for the customization of final products (postponement) is one of the activities that the ports would have to promote.

**Key resources** of Ports in 2040 would be the digitalization of their infrastructure as well as their adaptation to the moderate increase in ship size. Ports would have to invest in IoT hardware to respond to the digitalization and automation of transport. The evolution of new modes of transport (drones, truck platooning, etc.) would force the ports to adapt the services provided.

**Cost structures** would be heavily impacted, moving from the traditional capital investments in civil infrastructure towards investments in green ports and digitalization. Additionally, the energy transition in ports would need large capital investments to promote green initiatives. For example, for the deployment of on shore power supply (OPS) for vessels, the Port of Barcelona would invest more than 100 million euros.

**Revenue streams** from cargo flow would decrease, and ports would see an increase in revenue from the added value logistic service provided by the port. The new green energy model can also bring revenues to the ports.

To conclude with the BCM analysis, this flowchart summarizes the main new business models proposed and the structures needed to develop and promote them for 2040 for the case of the Port of Barcelona, considering the most relevant trends. These conclusions could be applicable to other European ports, as will be explained in the next section.

According to Kringelum (2019), port authorities are increasingly expected to manage business models as multi-sided platforms, which means managing interlinked business models that affect a plethora of port users and stakeholders with various expectations and requirements regarding value creation.

In this case study, different new business models have been detected by means of the BCM: green energy hub; intermodal and digital logistic hub; and a customization hub. The tools for the Port Authority of Barcelona to develop these new business models are: New governance and

agile models, and an Innovation hub of knowledge and training that would help to promote knowledge-based resources.

## 5. Discussion and implications for european ports

Analysing the BCM for the Port of Barcelona, certain conclusions could be extended to other European ports. Specifically, for those from the Mediterranean and south of Europe, that have a high specialization in logistics. In addition, as the PoB is a diversified port in terms of different activity sectors and traffic (see Fig. 1), the authors suggest that some of the future business models identified can be extrapolated to other ports. However, these results must be treated with caution, and adaptations must be made according to the typology of the port and the EU region where it is located. This is the reason why in this section we discuss the possible extension of the results of Fig. 4 to other EU ports.

According to port experts, the business model related to the promotion of the port as a **green energy hub** could be extrapolated to any EU port. The evolution towards green ports is going to be crucial for port competitiveness in global supply chains. In the VUCA (volatile, uncertain, complex and ambiguous) world defined by Spencer and Salvatico (2021), the role of energy in ports is changing rapidly and new energy business models will have to be adopted to reach sustainable goals. We can assume that the technology to facilitate green ports would likely have a relevant evolution in the coming decades. This technological development would be manifested both in infrastructure equipment (docks, on shore power supply infrastructures, etc.) and the different modes of transport (vessels, trucks, etc.). Uncertainties over what are the best solutions and how they can be adopted by the maritime and port industry are an important issue to be addressed by European policy makers.

Certain trends have an important influence, and they have forced ports to become **intermodal logistic hubs**. This future business models could only be relevant for other EU ports with a high specialisation in logistics and for those located in the Trans-European Transport Network (European Commission, 2022). The Port as a hub, is a function that goes beyond the classic role of a port oriented exclusively to the sea, which must grow and consolidate itself as a multidisciplinary space where all means of transport converge regardless of the origin and destination of the goods (Port of Barcelona, 2021). This involves being a port as well as a railway hub, and mainland and European land transport node for all types of goods, as well as a connection point between the sea and the airport for goods and people. The logistics hub function distinguishes it from transshipment ports and also, from gateway ports where goods simply come through from or to a remote location, and to which high value-added logistics processes (container cargo breaking, picking, packaging, postponement) are then applied. To sum up, a logistics hub provides high value-added logistics services to the hinterland and emerging sectors in Europe, as a result of the transition to a sustainable and innovative economy. It's an integrated platform linking logistics supply and demand.

Ports would have to develop new **business models related to customization**. According to the port experts participating in this research, this business model is valid for those ports with a relevant industrial hinterland with intensive import/export activities. For this reason, intensifying their vocation of adding value to the goods that passthrough ports would give a very competitive advantage. In this scenario, two innovations can play an important role: 3D manufacturing and e-commerce. Reducing labour costs due to companies' use of 3D printers can change the current scenario where first, product demand is forecasted, and then stock is manufactured (Garrido Salsas et al., 2021). Thanks to additive printers, products could be printed on demand much closer to the customer. In some cases, this could be done in small factories located inside ports, as they play an important physical role in the global logistic chain. With 3D printers, products can be customized for their final clients with a real-time response to demand. In that sense, the demand of e-commerce, characterized by its responsiveness, would increase the

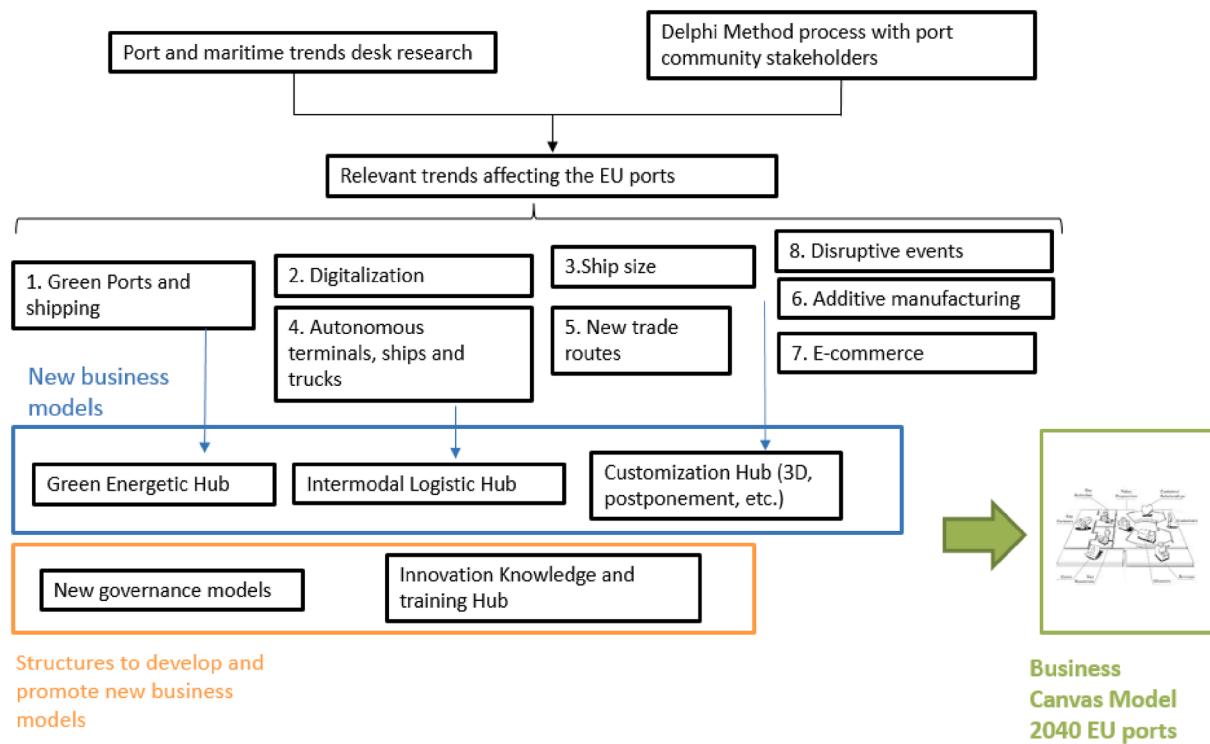


Fig. 4. New business models that could be extended to other European Ports. Source: Authors.

evolution of ports towards customization hubs. These processes of manufacturing or customization of products would take place within the port itself in logistic activity zones or in the port-city interface logistics ecosystem, to be later distributed to final consumers.

Two important structures to develop and promote future business models in ports would be relevant: governance and innovation. These structures are considered necessary for all ports in the EU if they want to deploy the future business models presented in this paper.

On the one hand, in terms of **port governance**, these trends would require important partnerships between the private sector and the Port Authorities (De Martino et al., 2020). In the past, technological developments, the need for financing new investments, the specialization of traffic, and profit expectations were some of the reasons that facilitated the entry of private capital into ports. In most cases this was transferred to landlord port management models. In the future, this public-private collaboration would be more intense, making it easier for ports to be managed more like a private company than a public administration. This is a trend that has in fact already been occurring in recent years. The increased involvement in partnerships would lead to more risks for Port Authorities.

On the other hand, an important added value of ports in order to be competitive and provide benefits to the hinterland economy is the development of a **knowledge, innovation and training hub**. This hub must vertically integrate the areas of logistics, transport, port management and green and blue economy with meeting spaces to facilitate the implementation of new companies and start-ups of the sector. This would also facilitate relations between administrations, research centres, and industry. Ports need to interact with a powerful research environment to meet new challenges in the industry. This can also help decision-making and the rapid dissemination of new ideas and technologies associated with the business models mentioned above. In fact, rapid implementation of innovations is a key factor in preventing port commoditization.

Finally, the extension of this future value proposition would be enforced if Port Authorities are able to establish intercontinental links. The evolution from a gateway or region towards continental linked ports

would be a key important driver. Intercontinental linked ports would benefit from standardization of operations, real-time information sharing, innovation technology exchange as well as shared strategy and preferential relationship.

## 6. Conclusions

The aim of this paper has been to explore with a novel methodology the impact of current trends on future business models of ports. The Business Canvas Model has been the framework tool used to analyse the present and the future PBE. The research is supported with a trend analysis that allows a BCM for 2040 to be constructed. The methodology has been applied for the case study of the Port of Barcelona, which allows some of the conclusions obtained to be extended to other EU ports.

Based on the case study of the Port of Barcelona, relevant results and conclusions have been obtained. Three business models for ports of the future (2040) have been identified: 1) green energy hub model, based on the production of renewable energy, storage and distribution of electricity and sustainable fuels; 2) Digital Intermodal hub model with intensified advanced logistic activities, based on real-time information sharing with digital twins to facilitate, among others, the track and trace of goods and passengers; c) New manufacturing activities especially related to 3D printing or other customization services integrated into the logistic supply chain.

To develop this new business model, Port Authorities would need to establish new organizational structures: resilient and flexible governance models with customers and partners. Ports would have to balance the need to capture monetary value to stay competitive whilst maintaining a dual focus on both environmental and socio-economic value.

The results of this research suggest a variety of future business models for EU Ports for the next decades. The new value creation would force ports to promote knowledge-based resources by means of a Hub of innovation, involving knowledge and training activities offering new solutions and supporting the transition towards a Port 4.0. Port authorities would be forced to transition from a more facilitating role towards a more entrepreneurial role in which innovation is very important

(Van Der Lugt et al., 2015).

Although the Business Canvas Model is a fairly innovative practice in the field of ports, this research defines a novel methodology to applying it and provides a case study of the Port of Barcelona as an example of its implementation. It's important to mention that this methodology has its limitations since PBE are complex entities and the sum of activities and services is very diversified. Therefore, it could be difficult to reach and engage all the port community experts to participate in the development of the BCM.

One of the limitations of the results paper is that the case study is focused on a specific European port of the Mediterranean, which does not allow generalisation of the BCM presented for 2040 in section 4.3 to ports in other parts of Europe. Different economic, social, geographic, or environmental characteristics arise in other ports over Europe. Therefore, the authors recommend redeveloping this methodology if the port to be analysed has relevant differential characteristics (i.e., traffic, geographic location, sectors specialization, etc.).

This way of studying ports allows for a more comprehensive and global approach in all areas related to port activities, without exhausting all possible ideas. This research is very useful for port strategy decision makers in order to have a long-term port vision based on a simplified BCM, allowing them to consider relevant insights to explore further.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgements

The authors would like to thank the Port of Barcelona, and particularly the staff of its Department of Innovation and Strategy, for its financial support in producing this paper.

### Author contributions

The authors contributed to the paper as follows: study conception and design: Javier Garrido, Sergi Saurí and Carles Rúa. All Authors contributed to the analysis and interpretation of results and to draft manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

### References

- De Langen, P.W., 2004. Governance in Seaport Clusters. *Marit. Econom. Logist.* 6 (2), 141–156.
- De Langen, P. W., Henrik Sornn-Friese and James Hallworth, 2020. The Role of Port Development Companies in Transitioning the Port Business Ecosystem: The Case of Port of Amsterdam's Circular Activities.
- De Martino M., Fabio Magnotti, Alfonso Morvillo, 2020. Port governance and value creation in the supply chain: The case of Italian ports, *Case Studies on Transport Policy*, Volume 8, Issue 2, Pages 373–382, ISSN 2213-624X, Doi: 10.1016/j.cstp.2019.10.004.
- European Commission. Trans-European Transport Network (TEN-T). [online] Available : <https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t-en>. Accessed 4 April 2022.
- F. Spencer , Y. M. Salvatico, "Creating strategy in a VUCA world," 12 November 2021. [Online]. Available: <https://thefutureschool.com/2021/11/creating-strategy-in-a-vuca-world/>. [Accessed 18 March 2022].
- Fahim P., Sotomayor M., Rezaei J., Binsbergen A., Nijdam M., Tavasszy L., 2021. On the evolution of maritime ports towards the Physical Internet, *Futures*, 134, 102834, ISSN 0016-3287, Doi: 10.1016/j.futures.2021.102834.
- Garrido Salsas, J., Saurí, S., Raventós, E., Rúa, C., Torrent, J., 2021. Emerging Trends Defining the Future Role of Ports: Application of the Delphi Method. *Transp. Res. Rec.* 2676 (3), 571–585.
- González-Cancelas, Nicoleta, Beatriz Molina Serrano, Francisco Soler-Flores, and Alberto Camarero-Orive. 2020. "Using the SWOT Methodology to Know the Scope of the Digitalization of the Spanish Ports" *Logistics* 4, no. 3: 20. Doi: 10.3390/logistics4030020.
- Jansen, M., 2018. "A sustainable business model for ports" Accessed 22/03/2021. <https://maurice-jansen.medium.com/business-model-canvases-are-commonly-used-in-companies-to-gain-a-better-understanding-of-the-8257f8b11410>.
- Brümmerstedt, K. Fiedler, R. Flitsch, V. Jahn, C. Roregerand H. Sarpong, B. Saxe, S. Scharfenberg B., 2017. Digitalization of Seaports - Visions of the Future. *Fraunhofer Verlag*. ISBN 978-3-8396-1178-4.
- Kaliszewski, A., 2018. Fifth and sixth generation ports (5GP, 6GP) – evolution of economic and social roles of ports, pp. 1–31.
- Kringelum, L.T.B., 2019. Reviewing the challenges of port authority business model Innovation. *World Rev. Intermodal Transp. Res.* 8, 265–291.
- Li, W., Vanelslander, T., Liu, W., et al., 2020. Co-evolution of port business ecosystem based on evolutionary game theory. *J. shipp. trd.* 5, 20. <https://doi.org/10.1186/s41072-020-00072-0>.
- Flynn, M. Lee, P. Notteboom, T. 2011. The next step on the port generations ladder: customer-centric and community ports, in: T. Notteboom (ed.), *Current Issues in Shipping, Ports and Logistics*, Univer-sity Press Antwerp, Brussels.
- Martín-Alcalde E., Saurí, S., Ng Adolf K Y., 2016. Port-Focal Logistics and the Evolution of Port Regions in a Globalized World. *Dynamic Shipping and Port Development in the Globalized Economy: Volume 2: Emerging Trends in Ports*, 102–127.
- Nicolas Mat, Juliette Cerceau, Lei Shi, Hung-Suck Park, Guillaume Junqua, Miguel Lopez-Ferber, 2016. Socio-ecological transitions toward low-carbon port cities: trends, changes and adaptation processes in Asia and Europe, *J. Clean. Product.*, 114, pp. 362–375, ISSN 0959-6526.
- Nitsenko, V., Nyenno, I., Kryukova, I., Kalyna, T., Plotnikova, M., 2017. Business model for a sea commercial port as a way to reach sustainable development goals. *J. Secur. Sustainab. Issues* 7, 155–166.
- Osterwalder, A., Pigneur, Y. *Business Model Generation*, 2010. A Handbook for Visionaries, Game Changers, and Challengers; JohnWiley and Sons, Inc.: Hoboken, NJ, USA.
- Osterwalder, A., Pigneur, Y., 2014. *Value Proposition Design: How to Create Products and Services Customers Want*. John Wiley and Sons Inc: Hoboken, NJ, USA.
- Perboli, G., Musso, S., Rosano, M., Tadei, R., Godel, M., 2017. Synchro-Modality and Slow Steaming: New Business Perspectives in Freight Transportation. *Sustainability*. 9 (10), 1843. <https://doi.org/10.3390/su9101843>.
- Port of Barcelona, 2021. IV Strategic Masterplan (2021–2025) with a Port Vision 2040. Approved in January 2021.
- Cepolina, S., Ghiara, H., 2013. New trends in port strategies. Emerging role for ICT infrastructures. *Res. Transport. Busin. Manage.* 8, 195–205.
- Unctad Port Marketing and the third generation Port, TD/B C.4/ AC.7/14 1992 UNCTAD, GENEVA.
- Unctad The fourth generation port UNCTAD Ports Newsletter No. 19 1999 <https://unctad.org/system/files/official-document/posdtetibm15.en.pdf>.
- UNCTAD, 2021. Open data statistics. <https://unctadstat.unctad.org/FR/>.
- Van Der Lugt, L., De Langen, P. 2011. Hinterland strategies of port authorities: A case study of the port of Barcelona, *Res. Transport. Econom.*, 33, (1), Pages 6–14, ISSN 0739-8859, Doi: 10.1016/j.retrec.2011.08.002.
- Van Der Lugt, L., De Langen, P., Hagdorn, L., 2015. Beyond the landlord: Worldwide empirical analysis of port authority strategies. *Int. J. Shipp. Transp. Logist.* 7 (5), 570–596.
- Van der Lugt, L.M.; de Langen, P.W., 2018. Value creation and value capture in the port's business. In *Port Management, Cases in Port Geography, Operations and Policy*. Pettit, S., Beresford, A., Eds.; Kogan Page: London, UK, pp. 13–27.