

## Article

# Management Innovation for Environmental Sustainability in Seaports: Managerial Accounting Instruments and Training for Competitive Green Ports beyond the Regulations

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**Abstract:** In the last 30 years, environmental sustainability has been receiving increasing attention by scholars and operators. All the seaport stakeholders, including port authorities (PAs), policy-makers, port users, any port stakeholders, and local communities, must invest substantial resources to achieve high competitiveness with respect of the environment. Drawing from the extant regulations system and conducting a deep review of the main contributions on the phenomenon, this conceptual study suggests managerial accounting instruments and training, which are still under-researched, as effective measures for enforcing and encouraging green port development. This three-step study consists of a systematic review of the regulatory frameworks and literature on the phenomenon, and an outline of the gap of the legislative framework and research, from a management innovation perspective, where effective managerial practices for environmental sustainability are not successfully suggested and implemented within seaports. On the one hand, the Balanced Scorecard and Tableau de Bord are identified and proposed as managerial accounting instruments for assessing, monitoring, measuring, controlling, and reporting the organizational processes of port players, mainly PAs, for developing competitive green ports. On the other hand, training has been suggested to educate and guide the human resources at all organizational levels within seaports, for supporting and developing awareness and behavioral attitudes in the direction of environmental sustainability.

**Keywords:** environmental sustainability; seaport; port authority; managerial accounting instruments; Balanced Scorecard; Tableau de Bord; training; management innovation

## 1. Introduction

In the last three decades, researchers, institutions, and operators have been paying increasing attention to the environmental impact of port and shipping operations. The port and shipping industry had to adhere to rigid scrutiny and follow rules systems in terms of environmental regulatory compliance, because of the high price related to climate change derived from their activities and operations. The environmental sustainability issue represents one of the three identified dimensions of sustainability, beyond the economic and social dimension [1,2].

The environmental issue is primarily and usually associated with “vessel and cargo handling operations, industrial activities in ports, port planning and extension initiatives and hinterland accessibility” [3]. Additionally, public institutions and society in general strongly force ports to perform their social responsibility [4]. Therefore, ports increasingly improve “their image, as part of

their corporate responsibility (CR) profile”, to appear “environmentally aware and sustainable” in responding to local community pressure and normative requirements [5] (pp. 292–295).

To achieve environmentally aware and sustainable behavior is challenging because it regards different features, such as the reduction of emissions from existing and future port activities or the modification of the logistics area. Thus, policymakers who develop strategies and policies in port management must consider the environmental issue in moving to the development of green ports. That is, ports must adopt a proactive orientation toward the development, implementation, and monitoring of effective practices addressed to reduce a port’s environmental impact [5–9].

The literature on this issue is still lacking, and further research is needed to identify and analyze concrete port industry requirements. After all, in order to support the decision-making processes of port authorities (PAs) in particular as regulatory institutions within seaports, and any port stakeholders in general (carriers, shippers, transport operators, labor and government bodies, etc.), environmental regulations should also provide guidelines about the adoption of instruments and information systems able to assess, monitor, and measure the effects of environmental sustainability choices, and to control and report the effectiveness and efficiency of the decision-making processes from a perspective of innovation. After all, the environmental regulations framework requires a strategic reply by the players involved in the sea-land processes related to transport flow management. Therefore, it is necessary to figure out how the ports can perform in different ways, that is more efficiently through open data, Internet of Things (IoT), or digital platforms, where sustainable energy is supported by the managerial instruments that are able to mix the port strategies and the organizational and managerial innovations for the competitiveness of the ports.

This conceptual paper consists of a three-step study. Firstly, we systematically review the regulatory frameworks on environmental sustainability in the port industry at the international and European level, evidencing specificities of some EU countries regarding national regulations on the topic. Secondly, we conduct a systematic review of the main contributions of the literature on this phenomenon. Thanks to this review, a research gap has been identified: the regulations and the literature are still scarce in suggesting and identifying useful and effective managerial instruments that are able to develop environmentally aware and sustainable behaviors of ports. Finally, we identify and propose some managerial instruments to fill the regulatory and research gap. Consequently, our research question is: if and how should the managerial instruments, such as the Balanced Scorecard, Tableau de Bord and training systems, be considered and used to develop the management innovation processes to achieve environmental sustainability within the port industry?

In the realm of normative requirements, the adoption of rules does not only concern monitoring and reporting activities (such as certifications and permissions), but it also requires the consideration of specific green behavioral orientation. Measurements, control instruments and training systems need to be implemented to allow all port players, that is the various port stakeholders (including shippers, carriers, or responsible institutions, such as port authorities), to make choices regarding the effective and efficient management of environmental impacts that are derived from their operations and activities by putting management innovations into practice. A broad reading of the proposed managerial instruments can fill the still existing gap in the regulatory and research frameworks.

According to the management innovation approach, we identify and suggest two different paths to address the environmental sustainability challenge within seaports. On the one hand, the managerial accounting instruments, the Balanced Scorecard (BSC) and the Tableau de Bord (TdB), which are already sometimes applied in the seaports, have been suggested and investigated with a specific goal (that is for the assessing, monitoring, measuring, and control of the performance of port players, the various stakeholders, mainly PAs, in terms of their impact on environmental sustainability). On the other hand, training has been proposed and analyzed for educating and developing strong and ethical ideals in the direction of environmentally sustainable behaviors among all human resources. These tools guide and support port players in finding the right path to follow and implement environmental policies and make them able to feel the relevance of environmental sustainability regulations, and to go

beyond the obligation to simply respect them. Thus, this theoretical paper outlines the limitations of the legislative framework, which is not able to successfully provide and implement these instruments for the environmental sustainability of ports and proposes specific managerial solutions according to management innovation perspectives with the aim of developing competitive green ports while also focusing on the educational needs in this direction.

The paper is organized as follows: Section 2 presents the methodology adopted for the study. In Section 3, the international and European legislative frameworks are briefly investigated, also highlighting insights from some EU countries. Section 4 provides a deep review of the main contributions of the literature on the environmental impact of port operations and development, giving a clear scenario on the phenomenon and highlighting the existing gap in the research. Section 5 focuses on the managerial accounting instruments (BSC and TdB) and training that can provide the conditions for management innovation regarding processes and measures for the sustainable development of green ports. Finally, Section 6 presents concluding remarks and suggestions for future research.

## 2. Methodology

This conceptual paper consists of a three-step study on the environmental sustainability of the port and shipping industry in the direction of adopting managerial instruments that are useful in developing management innovations within processes of public administrations in managing the port businesses.

First, adopting the PAs perspective, we analyze and summarize the regulations existing on the topic at the international and European level. Additionally, we focus our analysis on the regulatory framework of the main European countries where ports handle significant traffic flows and perform the most relevant environmentally aware and sustainable behavior such as Spain, the United Kingdom, France, Netherlands, and Germany [10]. The regulations and rules systems are briefly analyzed, showing the tendencies of the overall port and shipping industry regarding the environmental issues and managing innovation such as the actions of creating and capturing value from new technologies, processes, methods, and organizational models.

Second, we conduct a deep review of the main studies in the literature on environmental sustainability issue within the port industry for systematizing and evidencing the main research orientation of scholars and the still-existing research gap.

A broad review of the literature has been conducted, considering only published studies in the maritime field clearly focused on environmental issues within the port industry over a 20-year period (1997–2017). We conducted an online search using both, in a complementary way, the ISI Web of Science (WoS) and Google Scholar (GS), the most used web search databases specializing in academic literature. We adopted and combined the keywords “environmental sustainability”, “green ports”, “environmental pollution from ships”, “seaport industry”, “managerial and economic perspective”, “control measurement for environmental performance”, “environmental performance”, “port authorities”, “training”, “environmental training” and “sustainability training”. Journals were selected and checked from the ISI Web of Science Journal Citation Reports, 2016 Edition, in the categories of management, engineering, transportation, and other topics.

The following criteria were used for selecting papers. First, the papers had to have been published in English and at least one of the selected words and terms had to have been contained in their titles directly or indirectly. Second, the articles had to have dealt with research issues, mainly classified in the management category. We did not select articles only considering high impact factor journals (for example, *Energy Policy*, *Maritime Policy & Management*, *Sustainability*, *Business Strategy and Environment*), and we also considered journals of relatively lower ranking (for example, *Urban Policy and Research*, *The Asian Journal of Shipping and Logistics*).

We perused the abstract of each paper from the search results and then read the complete paper after determining its relevance in order to emphasize specifically the role of port players (among the various stakeholders especially PAs as the main regulatory institution) in two areas: (1) assessing,

monitoring, controlling, measuring, and reporting their choices in regard to competitive green ports, focusing the attention on environmental performance; and (2) educating and training these port players for adopting environmentally sustainable behavior. In the web search we emphasize the role of port authorities focusing the attention on the environmental sustainability of the port industry, and the managerial instruments linked to the management innovation processes that are used to manage the port businesses.

Finally, thanks to the review conducted, especially by considering studies by Puig and colleagues [11,12], Puig and colleagues [13], Puig et al. [14], Segui et al. [15], Peris-Mora et al. [16] and Denktas-Sakar and Karatas-Cetin [17], we investigate the environmental sustainability phenomenon in the seaports identifying and suggesting managerial accounting instruments and training as useful and effective solutions overcoming the limitations of the current environmental regulations and literature.

### **3. Regulatory Framework on Environmental Sustainability within Port Industry (in This Section, Most Parts Are Freely Drawn from Existing Regulations)**

Environmental sustainability has been broadly considered by the port and shipping regulatory frameworks. The environmental impact of the port and shipping industry is becoming an increasingly important issue to protect both coastal wildlife and port city destinations.

Regarding the port industry, the environmental pollution from ships is often due to their technical characteristics. For instance air pollution is generated by diesel engines that burn high-sulfur-content fuel, known as bunker oil; other pollutants include sulfur dioxide (SO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>) (Bailey & Solomon, 2004). However, other issues that also have an impact on environmental pollution, specifically within the marine environment, include ballast water discharges and noise production by ships. These dimensions have been considered and framed into different regulations at the international and European levels. Over the years the main international institutions, such as the International Maritime Organization (IMO) and the Marine Environment Protection Committee (MEPC), have produced continuous and deep interventions, consisting of amendments, regulations, standards, and proposals of guidelines related to the MARPOL 73/78/97 international convention, which is the most relevant and specific legal intervention on environmental issues in the port and shipping industry. Over recent decades, the IMO (the United Nations specialized agency with responsibility for both the safety and security of shipping) has also focused on the prevention of marine pollution by ships and has introduced several conventions on environmental pollution issues. The main convention, the “International Convention for the Prevention of Pollution from Ships”, was introduced in 1973 (MARPOL 73) and amended the International Convention for the Prevention of Marine Oil Water (OILPOL 54). This convention was amended by the 1978 and 1997 protocols, signed during the TSPP (Tanker Safety Pollution Prevention) Conference and planned because of the environmental disasters caused by oil tankers in the late 1970s. The convention, known as MARPOL 73/78/97, deals with the prevention of pollution of the marine environment by ships from operational or accidental causes. It regulates the draining standards for used oil, sewage, and waste materials and is structured by six annexes entered into force from 1983–2005.

Within the European context, numerous legal interventions concern environmental issues for the seaport industry. The European Union (EU, Brussels, Belgium) supports ambitious international actions addressing instruments to prevent global warming and has implemented policies able to create environmentally aware and sustainable ports (for instance, by facilitating the transition to a low-carbon economy). The EU’s interventions addressing these challenges aim to guarantee environmental sustainability in the seaport industry (directives 2012/33/EU, 2012/27/EU, 2014/94/EC; EU Regulation no. 2015/575) (for a summary see Table 1).

Furthermore, it is necessary also to mention the Environmental Impact Assessment Directive (European Directive 1985/337/EU), which requires a significant environmental assessment for port development and the Habitats Directive (European Directive 1992/43/EU), which invites port managers to pay increasing attention to the impact of industrial activities on species or habitats close to ports [18].

**Table 1.** International and European regulations on green ports (environmental sustainability in ports).

Geographic Competence	Year	Organization	Content
International	2013	IMO (International Maritime Organization that is United Nations Agency with responsibility both for safety and security of shipping, London, UK)	The Marine Environment Protection Committee (MEPC, London, UK), IMO's technical work, pushed forward with "energy efficiency" implementation, promoting technical Co-operation and transfer of technology to improve the energy efficiency of ships, also requiring an update to the greenhouse gas (GHG) emission estimate for international shipping.
	2011		Adoption of chapter for covering "mandatory technical and operational energy efficiency measures" addressed at decreasing "greenhouse gas emission" from vessels.
	2009		The Hong Kong International Convention for the safe and environmentally sound recycling of the ships.
	2004		The International Convention for the control and management of ships ballast water and sediments.
	2000		A Protocol to the OPRC relating to hazardous and noxious substances (OPRC-HNS Protocol).
	1997		MARPOL 97 with amendments for MARPOL 73/78 specifically with the Annex (VI). In fact, the "1997 Protocol", which included Annex VI titled "Regulations for the Prevention of Air Pollution from Ships", amends MARPOL 73/78.
	1996		Protocol to the London Convention 1972 for regulating the use of the sea as a depositary for waste materials and finding a balance between the concentration of CO <sub>2</sub> in the atmosphere and the marine environment to guarantee the new technology (Entry into force: 2006).
	1990		The International Convention on oil pollution preparedness response and Co-operation (OPRC) (Entry into force: May 1995).
	1973		The Annex I regards the prevention of environmental pollution due to the discharge of oil and oily water into the ocean. It provides regulations related to the treatment of engine room bilge water (Oily water separator, OWS) for large commercial vessels, and ballast and tank cleaning waste (Oil discharge monitoring equipment, ODME), and it introduces the concept of "special sea areas" (Particularly Sensitive Sea Area, PSSA), focusing the attention to the ocean areas mainly characterized by high risk for oil pollution. The Annex II concerns the control of pollution noxious liquid substances in bulk, by introducing also detailed operational standards and measures. Then, the following four annexes focus on the prevention of environmental pollution by specific sources, such as harmful substances, called also marine pollutants, carried by sea in packaged form (Annex III), sewage (Annex IV) and garbage from ships (Annex V) and the prevention of air pollution from ships (Annex VI). This last annex introduced limits on sulfur oxide (SO <sub>x</sub> ) and NO <sub>x</sub> from ship exhausts and prohibits the emissions of ozone depleting substances. It indicated the "emission control areas set" for SO <sub>x</sub> and NO <sub>x</sub> .
	1972		London Convention on the prevention of "marine pollution" by dumping of wastes and other matter.
European	2015	European Union (EU)	EU Regulation No. 2015/575 concerns the monitoring, reporting and verification of CO <sub>2</sub> emissions from maritime transport.
	2014		Directive 2014/94/EC concerns the deployment of alternative fuels infrastructure establishing a common framework of measures for the deployment of alternative fuels infrastructure in the Union to minimize dependence on oil and to mitigate the environmental impact of transport through the development of alternative fuels infrastructure, including recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and hydrogen.
	2012	European Union (EU)	Directive 2012/33/EU regards the sulfur content of marine fuels. Directive 2012/27/EU concerns the energy efficiency.

Table 1. Cont.

Geographic Competence	Year	Organization	Content
		European Sea Port Organization (ESPO)	The ESPO Green Guide (2012) introduces measures to improve the environmental performance, focusing on five actions, such as: exemplifying (setting a good example in the port community in managing successful environmental performance); enabling (creating operational and infrastructural conditions for facilitating port users and improving environmental performance within the port area); encouraging (giving incentives to port users for encouraging changes behaviors and continuously improving their environmental performance); engaging (sharing knowledge, means and skills between port users and/or competent authorities, also through jointed projects); enforcing (using mechanisms to enforce effective environmental practices by port users and ensuring compliance).
	2011	European Union (EU)	The Communication on an Energy Efficiency Plan 2011 confirms that the Union works on its energy efficiency target, evidencing the need to update the Union's legal framework for energy efficiency achieving the fixed goals.
	2009		Directive 2009/28/EC promotes the use of energy from renewable sources and amending, addressing the improvement of energy efficiency to achieve the 20% improvement in energy efficiency by 2020.
	2005		Directive 2005/33/EC, amendment of Directive 1999/32/CE, identifies some European zones as sulfur emission control areas (SECAs) specifying the maximum limit for sulfur content of the fuels used by ships operating in these sea areas.
	2006		Directive 2006/32/EC regards the energy end-use efficiency and energy services.
	2005		Directive 2005/35/EC concerns the ship-source pollution introducing penalties for infringements.
			Directive 2005/33/EC regards the sulfur content in the fuel used by ships with focus on air pollution in the form of sulfur dioxide and particulate matter, harming human health, damaging the environment, public and private property and cultural heritage, and contributing to acidification.
	2004		Directive 2004/8/EC concerns the promotion of cogeneration based on a useful heat demand in the internal energy market.
	2003		Directive 2003/55/EC introduces relevant rules concerning the energy environment with focus on internal market in natural gas.
	2002		Directive 2002/49/EC aims at achieving a common approach towards environmental noise, deeply affecting the European ports regarding noise pollution with negative effects for human health in the coastline and all the territory.
	2001		Directive 2001/42/EC, well known as SEA Directive introduces the concept of "environmental assessment and reporting", specifically, the evaluation of the environment effects by certain plans and programs ("environmental assessment and reporting").
	2000	European Commission	Directive 2000/59/EU regulates the port reception facilities for ships which generated waste and cargo residues, by establishing the "polluter pays" principle and a "producer responsibility", for port and ship which generate waste, and emphasizing the concept of preventing.
	1999		Directive 1999/32/EC contains the first requirements about the sulfur content of gas oils and addresses the sulfur content of heavy fuel oil, heating oil and marine fuels following the incorporation into EU law of rules adopted by IMO (regulation of sulfur emissions by ships).
	1969/1971		The Convention on the high seas in the event of accidents for oil pollution adopted in Brussels in 1969, the Convention on Civil Liability for Oil Pollution Damage adopted in Brussels always in 1969 subsequently amended, and the Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage from Ships in Brussels in 1971.



Interesting results can be found regarding the relationship between shipping and ports in terms of pollution emissions. Indeed, the OECD [19] has examined the environmental impact of international maritime transport in five ports: namely, Los Angeles and Long Beach (CA, USA), Rotterdam (The Netherlands), Vancouver (Canada), and Busan (Korea). Public authorities have put in place a wide range of instruments and management policies for reducing the negative environmental impacts from ports in relation to: near-port shipping activities (for example, limits on the sulfur content of the fuels that may be used and requirements regarding the treatment of ballast water); the handling of the goods in the ports (for example, emission standards for the handling equipment and limits on permitted noise levels); and the transport of the goods to the hinterland (for example, emission standards for vehicles used in the transport, and investments in better road and rail infrastructure). From the perspective of management innovation, the type of managerial instruments applied significantly varies and includes the following initiatives: “soft” instruments like information provision; bans on certain activities (for example, the use of antifouling containing biocides); standards on input use (for example, on sulfur contents in fuels); technologies to be applied (for example, double-hulls on tankers); emissions (for example, regarding goods-handling equipment); and various sorts of economic incentives (for example, differentiated port dues). In many cases, compared to bans and standards, managerial instruments can provide more flexibility for polluters to find low-cost opportunities to reduce negative environmental impacts. As mentioned, numerous managerial instruments are being applied to address the negative environmental impacts of port and the related shipping activities. However, the managerial instruments used in this sector have often a “prescriptive” nature and are unlikely to change the fundamental economic incentives that generate innovations to address the underlying environmental problems at a lower cost. One reason for this element is the lack of a global framework for addressing the environmental impacts of international shipping, making it difficult for single countries to take action that would “internalize” the climate change impacts (for example, by putting in place a carbon tax on bunkers). Another reason arises from the difficulties involved in monitoring and enforcing such actions (for example, a tax on the real SO<sub>2</sub>, NO<sub>x</sub>, or noise emissions from each ship) [19].

#### *Regulatory Framework on Environmental Sustainability: Insights from Some EU Countries*

Among the European countries we focus on Spain, UK, the Netherlands, France, and Germany. Most Spanish, UK, Dutch, French and German environmental laws within the maritime and port industry derive from the transposition of EU legislation, where the main regulated environmental fields concern integrated environmental control, natural heritage and biodiversity protection, the air quality and atmosphere protection, environmental responsibility, nuisance activities, environmental impact assessment, contaminated land and waste management.

Especially in Spain, the Ministry of Public Works approved a plan for savings, energy efficiency and emissions reduction in transport and housing. Its main target is to promote environmentally friendly modes of transport and encouraging the use of so-called “Motorways of the Sea”. It includes specific measures to reduce CO<sub>2</sub> emissions in the maritime transport, increase energy efficiency in port terminals, and promote energy efficiency in port services.

Specifically, since the nineties, in Spain a deep process of regulatory evolution regarding the structure and management of state port system occurred, up until the most recent intervention, which is the Royal Legislative Decree 2/2011, the current state port system main regulation which revised the previous laws, with the approval of the Revised Text of the Law on State Ports and the Merchant Marine (TRLPEMM due to its Spanish initials). The TRLPEMM has been significantly modified thanks to the following interventions, especially regarding the issue of environmental sustainability in the port industry. Indeed, the main modifications on the topic were Law 2/2013, on the protection and sustainable use of the coastline including changes of Law 22/1988, focused on coasts, and also the Royal Decree Law 8/2014, which approved urgent measures for growth, competitiveness, and efficiency, as well as, later, Law 18/2014. Then, Law 14/2014 introduced significant rules about marine navigation which deals with pollution control and liabilities in field shipping.

Furthermore, Law 33/2015, revising Law 42/2007, on natural heritage and biodiversity, aimed to improve certain aspects, such as the management of environmentally protected areas, the incorporation into the Spanish legal system of obligations derived from EU legislation and international protocols ratified by Spain. This law also addressed competence between the central and the regional governments in marine environment related matters considering recent court rulings from the Spanish Constitutional Court.

Also, some measures were introduced to simplify and speed up the preparation of reports for increasing knowledge of the natural heritage and biodiversity and to include the Land Registry of environmental information related to real estate.

Furthermore, the Spanish government plans to start working on the amendment of the Ports Law in the country in 2018 to incorporate environmental sustainability criteria in the regulation. With this concern, the president of the National Ports Agency (Puertos del Estado, Spain), José Llorca, argued the need to make the regulation more flexible in terms of environmental bonuses. In this direction, the reform must respond to the requirements of ports such as Barcelona, which has been advocating for the extension of bonuses to ships using technology that causes smaller contaminations.

The energy model, that is being introduced in Spain under the example of more developed countries, with a focus on renewable energy, could cause tensions in some ports that rely on coal traffic. Therefore, the ports need to attract new types of traffic and more sustainable industrial activities. For more details see <http://www.portseurope.com/spanish-government-to-introduce-environmental-sustainability-criteria-in-ports-law/> (access: 7 February 2018).

The UK implemented the Directive 2007/71/EC and the Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities for ship-generated waste and cargo residues through the Merchant Shipping and Fishing Vessels (Port Waste Reception Facilities) Regulations 2003 (SI 2003/No: 1809) as amended by the Merchant Shipping and Fishing Vessels (Port Waste Reception Facilities) (Amendment) Regulations 2009. These Regulations have been named in this MGN (Marine Guidance Note) as “the 2003 Regulations as amended”. These regulations also are enriched from the detailed guidance for Harbor Authorities and terminals undertaking Port Waste Management Planning (PWMP). This guideline is available in the booklet “Port Waste Management Planning—A Guide to Good Practice” and can be obtained from the Maritime and Coastguard Agency (MCA) Marine Offices or viewed on the MCA website at <http://www.mcga.gov.uk/c4mca/guidetgpf-finalversion.pdf> (access: 7 February 2018).

As suggested and stated by the EU Directive EC85/337 (later altered by EC97/11), the UK ports need to conduct an environmental audit which covers inter alia handling and storage areas of prescribed materials, waste emissions, spoil disposal areas, fishing, wetlands and zones of specific scientific or cultural interest, compliance with conventions and codes concerning marine pollution and dangerous goods, and prioritization of environmental protection issues. Although audits are not mandatory, port managers have liabilities for any environmental damages with sanctions. Also, the British Ports Association (BPA) environmental code of practice addresses environmental awareness among port employees and users, as well as other relevant national regulations that significantly discipline UK ports with respect of environmental sustainability; for instance, the Coast Protection Act (1949), the Dangerous Substances in Harbor Areas Regulations 1987, the Environmental Protection Act 1990, and the previous International Regulations for Preventing Collisions at Sea 1972, or the Merchant Shipping Regulations (Oil Pollution Preparedness Response and Co-operation Convention & Port Waste Reception Facilities) in 1997. Among the numerous regulations and laws on environmental sustainability issues in UK ports, the Merchant Shipping Regulations 1988 (Oil Pollution Preparedness, Response and Co-operation Convention) which require to UK ports, harbors and oil handling facilities to prepare and submit oil spill response contingency plans to the Maritime and Coastguard Agency (MCA) for approval are also relevant.

Since the early 1990s, the Netherlands has made considerable progress in respecting the environmental sustainability regulations and laws in the port and shipping industry, especially considering that this country represents one of the most important hubs of international



commerce, where the port of Rotterdam (the busiest port in the world) is the center of the transport infrastructure. Dutch regulations and laws in the port industry have some specific priorities related to environmental sustainability, that is loss of biodiversity, climate change, over-exploitation of natural resources, threats to human health and external safety, damage to the quality of life, and possible unmanageable risks. A framework for coordinating environmental legislation, though water, soil, and nature management, is provided from the Environmental Management Act (EMA). New regulations have been introduced in recent years, such as rules about environmental taxes (e.g., on groundwater, landfill) and a regulatory energy tax. Most previous National Environmental Policy Plan targets for emission reductions and for environmental quality have been significantly modified.

In France, as well as in other EU countries, many regulations about the environmental sustainability issue in the port industry derive from general laws and legal interventions regarding the government program to reduce and prevent negative impacts on environment of any industrial and economic activities and processes, such as the Grenelle I Act (2009) and the Grenelle II Act (2010).

In Germany, the government continuously works on accompanying German legislation to specify any details, such as responsibilities and sanctions, for instance the most recent Shipping Law in 2017 concerns many issues in shipping laws and regulations, including marine casualty, cargo claims, passenger claims, arrest and security in the overall country, especially regarding air and water pollution, with Federal Water Management Act and the Environmental damage Act.

Thanks to the review of the regulatory frameworks at the international and European levels, it is clear that all these regulations seem still incomplete; in fact, several scholars have already showed the inadequacies of the regulatory frameworks and the enormous challenges faced for implementing them [20,21], especially because they still do not provide any suggestion about managerial instruments for assessing, monitoring, measuring, and controlling environmental impacts of the port industry, although these limitations also can be explained because of the typical restrictive nature of the same regulations. The regulatory framework is still missing in analyzing and suggesting the ways to address environmental sustainability for ports.

#### 4. Review of Environmental Sustainability Literature for Ports

Environmental sustainability constitutes one of the three different frameworks for sustainability beyond the social and economic dimensions, defining the so-called “triple bottom line” for sustainable development since the early 1980s [22,23]. The social dimension regards the need to reduce any negative impacts from industrial activities. The economic dimension concerns the efficiency of business operations, balancing resources used for manufacturing products and offering services to people. The environmental dimension, on which this study focuses, addresses the preservation and protection of natural resources for future generations. In general, thanks to the balance of these three dimensions, it has been possible to promote sustainable development [1], with a strong link to corporate social responsibility (CSR), which is the need for any business to adopt ethical behaviors and to promote economic development by improving the quality of life for all employees, their families, and society overall [24]. The broad phenomenon of CSR includes five dimensions. They are the environmental, social, economic, stakeholder, and voluntariness dimensions [25]. Otherwise, considering specifically port sustainability, Doerr [26] distinguishes between four dimensions: the environmental, social, economic, and institutional.

The research review outlined a total of about 157 papers and most of them are conceptual studies or adopt a qualitative methodology (mainly case study methodology). Numerous countries are involved in the case studies, including countries from Asia (Japan, Thailand, and China), Central Europe (Germany, the UK, Greece, Spain, and Italy) and America (Brazil, Venezuela, and the U.S). It is interesting to observe that some of the studies are the result of joint investigations by industry and academia concerning environmental sustainability [27–38].

In the last five years, it has been possible to record the highest number of papers on the topic. In 2017, 24 papers were published (see Table 2).

**Table 2.** Literature Review web search 1997–2017.

Year	Art	Journal	Subtopic	Author(s)	Methodology
1997	1	Science	Ship Emissions, Air Pollution, Water Pollution	Corbett, Fischbeck, (1997)	Conceptual study
1998	1	Geographical Journal	Sustainable Management, Water Pollution Management	Turner, Lorenzoni, Beaumont, et al., (1998)	Qualitative methodology: Coastal areas evaluation in UK for evidencing the environmental impact through the ecosystem-function-based valuation methodology.
1999	1	Marine Policy	Environmental Management, Monitoring Practice, Environmental Sustainability, Ports and Harbors	Wooldridge, McMullen, Howe (1999)	Qualitative study (Case study methodology)
2000	2	European Management Journal; Global Nest: The International Journal	Environmental management System, Environmental sustainability Port Pollution, Port environmental protection, Port environmental policies, European Union environmental policies	Steger (2000) Goulielmos (2000)	Conceptual study and Qualitative study (Multiple case study)
2001	2	Corporate Social Responsibility and Environmental Management; Marine Policy	Environmental Management, Sustainability, Pollution Prevention, Eco-efficiency Environmental regulation, Environmental Performance	Dias-Sardinha, & Reijnders (2001) Bennett (2001)	Conceptual study (Theoretical study); Qualitative study (case study)
2002	1	Ocean and Coastal Management	Environmental Management, Environmental Sustainability, Education and Training in Environmental Sustainability	McConnell (2001)	Conceptual study (Theoretical study)
2003	3	Maritime Policy & Management, Atmospheric Environment, Journal of Geophysical Research: Atmospheres	Sustainability Assessment and Measurement Ship Emissions, Air Pollution Environmental Impact,	Gilman (2003) Cooper (2003) Endresen et al., (2003)	Conceptual and qualitative study (New Approach Transport Assessment in ports NATA approach in UK ports). Conceptual study and Qualitative study
2004	3	Marine Pollution Bulletin, Environmental Impact Assessment Review, Atmospheric Environment	Environmental performance, Environmental management, Sustainable development, Port management, Air Pollution, Pollution prevention, Ship emissions Environmental Sustainability, Ship Emissions	Darbra, Ronza, Casal, Stojanovic, Wooldridge (2004) Bailey & Solomon (2004) Saxe & Larsen (2004)	Conceptual and quantitative study (Survey field study on ports). Conceptual study (Review and State of Art) Conceptual Study and Quantitative and Qualitative study (Multiple case study)
2005	5	Marine Pollution Bulletin (2) Journal of Environmental Management, Clean Technological and Environmental Policy, Journal of Geophysical Research: Atmospheres	Key performance indicators for environmental performance measurement, Sustainable port management, Environmental economics, Ship emission Environmental management plan, Air Pollution, Waste Management Environmental Management System, Significant Environmental Aspects(SEA) Ship Emissions, Environmental Impact	Peris-Mora, Orejas, Subirats, Ibáñez, & Alvarez (2005) Gallagher & Taylor (2005) Gupta, Gupta, S.K., Patil (2005) Darbra, Ronza, Stojanovic, Wooldridge, Casal (2005) Eyring, Kohler, van Aardenne, Lauer (2005)	Theoretical study and Qualitative and quantitative methodology (Multiple case study methodology) Qualitative study (Case study method) Conceptual study and Qualitative study Conceptual study and Qualitative study (Multiple case study) Conceptual Study (review) and State of Art

Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2007	5	Urban Policy and Research, Journal of Environmental Economics and Management, Environmental Science & Technology (2), Atmospheric Environment	Aesthetic and Noise Pollution Management, Environmental economics, Air pollution, Ship Emissions, Air Pollution, GHG Emissions, Mortality, Air Pollutant Emission Inventory,	Szili, Rofo (2007) Muller, Mendelsohn (2007) Corbett et al., (2007) Yang, et al., (2007) Dore et al., (2007)	Qualitative study (Case study method) Conceptual study and Qualitative study (Case Study)
2008	4	Ciencias Marinas, Environmental Science & Technology, Atmospheric Environment,	Marine Biology Prevention, GHG Emissions, Criteria pollutants, Gas emissions, Environmental Sustainability, Environmental Management, Ship emissions, Air Quality, Air Pollution	Morales-Caselles, Rico, Abbondanzi, et al., (2008) Agrawal, Welch, Miller, Cocker (2008) Vutukuru & Dabdub (2008)	Qualitative study (case study method) Conceptual study and Qualitative study (case study)
2009	5	Journal of Environmental Management, Atmospheric Chemistry & Physics, Transportation Research Part D: Transport and Environment, Atmospheric Chemistry and Physics	Port Environmental monitoring Marine data management Ship Emissions, GHG Emissions, Air Pollution, Water Pollution, Size and Type of ships Environmental Sustainability, Environmental Management, GHG Emissions, Ship emissions Environmental Sustainability, AIS data model, Marine Emissions, STEAM (Ship Traffic Emission Assessment Model)	Darbra, Pittam, Royston, Darbra, Journee (2009) Dalsoren, Eide, Endresen, Mjelde (2009) Gravir, Isaksen (2009) Corbett, Wang & Winebrake (2009) Jalkanen et al., (2009)	Conceptual study (Framework Model) Conceptual study and Quantitative> /Qualitative study (Multiple case study) Conceptual study and Qualitative study (Case study)
2010	11	The Asian Journal of Shipping and Logistics, Ocean & Coastal Management, Transportation Research Record: Journal of the Transportation Research Board, International Journal of Sustainable Development, Public works management & policy, Atmospheric Environment, International Journal of Logistics Research and Applications, Atmospheric Environment (2), Transportation Research Part D: Transport and Environment (2)	Air Pollution Management, Water, Land and Air Pollution Management Environmental Sustainability Development strategies GHG Emissions, Ship emissions, Port Emissions, CO2 Emissions Ship Pollution, Maritime air pollution, Green maritime logistics, Port Pollution, Port emissions	Esmer, Çetin, Tuna (2010) Ng, Song (2010) Cheon, Deakin (2010) Girard (2010) Linder (2010) Tzannatos (2010) Psarafitis, Kontova (2010) Tzannatos (2010) Leonardi, Browne (2010) Eyring et al., (2010) Winnes, Fridell (2010)	Qualitative study (case study method) Conceptual study (Theoretical framework) and qualitative study (Case study) Conceptual study (Theoretical framework) Qualitative study and Qualitative Study (Case study Methodology) Qualitative study (case study methodology) Conceptual paper and Qualitative study

Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2011	14	Energy Procedia, Geo-Eco-Marina, Optical Switching and Networking, Ocean & Coastal Management, Journal of Marine Systems, Physics and Chemistry of the Earth, Resources, Conservation and Recycling, Energy Policy (2), Maritime Policy & Management (2), Transportation Research Part D: Transport and Environment, Marine. Policy, Resources, Conservation and Recycling,	Air Pollution Management, Environmental Economy, Environmental Management Accidental pollution Environmental management, Operational oceanography, Water quality Environmental Management (EMS), Environmental al policy, Significant environmental aspect, Environmental Sustainability, Green Shipping Practices, Ship Emissions, Environmental Management, Greenhouse gas emissions (GHG), Environmental Management, CO2 emissions, Container shipping Emissions, Ship Emissions, Green Ports, Green management practice (GMP)	Ying, Yijun (2011) Anastasopoulos, Kolios, Stylios (2011) Hou, Guo, Wang, Wei (2011) Saengsupavanich (2011) Grifoll, Jorda, Espino, Romo, García-Sotillo (2011) Quynh, Hens, Stoyanov (2011) Lai, Lun, Wong, Cheng (2011) Villalba, Gemechu (2011) Fitzgerald, Howitt, Smith (2011) Kontovas, Psaraftis (2011) Eide, Longva, Hoffmann, Endresen, & Dalsøren (2011) Cariou (2011) Heitmann, Khalilian (2011) Lun (2011)	Conceptual paper and Qualitative study (Case study methodology) Qualitative (case study) and quantitative methodology. Qualitative and Quantitative methodology Qualitative study (Case study method) (Environmental Impact Assessment -EIA) system. Conceptual study and Qualitative study (Case study methodology) Conceptual study and Qualitative Study (Multiple case study) Conceptual study (theoretical framework) Conceptual Study and Qualitative study (Case study methodology) Conceptual study and Qualitative study (Illustrative examples) Conceptual study (Framework model, Data, and methodology proposal) Conceptual Study (Framework study and empirical evidence analysis) Conceptual Study (Theoretical analysis) Conceptual study and Qualitative study (Case study)

Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2012	17	Transportation Research Part D: Transport and Environment (3), Energy Policy, Journal of Environmental Planning and Management, Low Carbon Economy, Business Strategy and the Environment, Science of the total environment, The Asian Journal of Shipping and Logistics Research in Transportation Business & Management (2), Atmospheric Environment Energy Policy Transportation Research Part A: Policy and Practice Sustainability (2) Marine Policy	Environmental Economy, Green Port Development, Environmental sustainability, Corporate Social Responsibility (CSR) strategies Air Pollution Management Environmental Assessment, Ship emissions, Air Pollution Air Pollution Management Air Pollution Management Environmental Management (strategy) Ship Emissions, Automatic Identification System (AIS), Air Pollution, Air Quality Air Pollution Management Exhaust Pollution (Land, Water and Air Pollution) Environmental sustainability (Social and economic dimensions of sustainability) Environmental sustainability, Green ports, Corporate Social Responsibility Ship Emissions, Automatic Identification System (AIS), Air Pollution Environmental Sustainability, GHG Emissions, Ship Emissions, CO2 Emissions Environmental Sustainability, Cost Efficiency, Sustainable Development Environmental Sustainability, Greening Shipping, Clean Shipping Project Environmental Sustainability, Environmental Management	Bergqvist, Egels-Zanden (2012) Chang, Wang (2012) Bengtsson, Fridell, Andersson (2012) Carballo-Penela, Mateo-Mantecon, Domenech, Coto-Millan (2012) Fan, Dong, Zhang, Li, Liang (2012) Dinwoodie, Tuck, Knowles, Benhin, Sansom (2012) Yau, et al., (2012) Chang, Wang (2012) Berechman, Tseng (2012) Denktas-Sakar, Karatas-Cetin (2012) Bergqvist a, Egels-Zandén (2012) Ng. et al., (2012) Gilbert, Bows (2012) Iannone (2012) Cerreta, De Toro (2012) Wuisan, van Leeuwen, van Koppen, (2012) Attardi, Bonifazi, & Torre (2012)	Qualitative study (case study method) Green Port Fees and Marginal Costs. Quantitative methodology (SEM) Conceptual study and Qualitative study Qualitative study (case study method) and quantitative methodology: Conceptual study and Qualitative study (Case study methodology) Qualitative study (case study method) Conceptual study (Theoretical framework) Conceptual study (Theoretical framework) (Stakeholder Theory applied in seaports) Conceptual study and Qualitative study (Case study methodology) Conceptual study and Qualitative study (Multiple case study Methodology)

Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2013	15	Research in Transportation Business & Management, Transportation Research Part E: Logistics and Transportation Review (2), Rendiconti Lincei, Sustainability, Pakistan Journal of Statistics, Maritime Policy and Management, Transport Reviews, Ocean & Coastal Management, International Journal of Physical Distribution & Logistics Management, Research in Transportation Business & Management, Transportation Research Part D: Transport and Environment (3)	Environmental Economy Environmental Sustainability, Port Pollution, Port Emissions, Truck Emissions, Emissions Reduction Methodology Air Quality, Air quality in harbors Environmental Management, Air Pollution Management Regulation, Atmospheric Emissions, Air Pollution Sustainable Ports, Coastal development, Green Performance Criteria, Environmental Key Performance Indicators (eKPIs) Cold ironing Container Shipping Emissions, Greenhouse gas emissions (GHG),	Dooms, Haezendonck, Valaert (2013) Chen, Govindan, Golias (2013) Garcia, Cinquepalmi, & Cumo (2013) Borriello (2013) Sheu, Hu, Lin (2013) Klopott (2013) Cullinane, K., & Cullinane, S. (2013) Yap & Lam (2013) Lirn, Wu, Chen (2013) McArthur, Osland (2013) Yang, Haider, Marlow (2013) Yang, Chang (2013) Tai & Lin (2013) Chang, Song, Roh (2013)	Qualitative study (case study method) Conceptual Study (theoretical study) and Qualitative study (Case study Methodology) Quantitative and qualitative methodology (case study method) Conceptual Study (Theoretical study) Conceptual study and Qualitative study (Multiple case study) Quantitative study (Survey field study – Structural Equation Model SEM) Conceptual study (Framework model)
2014	18	Energy Policy (3), Thermal Science, Maritime Policy & Management (3), Transport Reviews, Mathematical Problems in Engineering, Marine Pollution Bulletin, Mathematical Problems in Engineering, Atmospheric Environment (2) Journal of Maritime Affairs, Revista de Gestão Costeira Integrada, Transportation Research Part D: Transport and Environment (2), Measurement, Journal of Cleaner Production (2)	Air Pollution, GHG emissions, Air Pollution Management, Energy Management, Green Ports, Environmental Sustainability, Environmental Management, GHG emissions Successful innovations, Green Port Development, Port Management Tools Green Performance Criteria Environmental Key Performance Indicators (eKPIs), (Hazardous waste handling, air pollution, water pollution, port greenery, and habitat quality maintenance) AIS Air Pollution Management, Ship Emissions, External Costs, Energy Efficiency Preventing and reducing time in port Sustainable development, Port environmental management, Port environmental practices CO2emissions, Environmental monitoring and control systems, Cold ironing Environmental Management System (EMS),	Gibbs, Rigot-Muller, Mangan, Lalwani (2014) Pavlic, Cepak, Sucic, Peckaj, Kandus (2014) Acciaro, Ghiara, Cusano (2014) Brynolf, Fridell, Andersson (2014) Acciaro, Vanelander, Sys, Ferrari, Roumboutsos, Giuliano, G., . . . & Kapro (2014) Lam & Notteboom (2014) Chiu, Lin & Ting (2014) Puig, Wooldridge, Darbra (2014) Chiu, Lin, Ting (2014) Gibbs, Rigot-Muller, Mangan, Lalwani (2014) Song (2014) Castells., Usabiaga Martinez (2014) Moon & Woo (2014) Hiranandani (2014) Viana et al., (2014) Chang & Wang (2014) Romero, Asmus, Milanelli, Buruaem, & Abessa (2014) Accorsi, Manzini, & Ferrari (2014) Adamo et al., (2014) Le, Vu, Hens, Heur (2014)	Qualitative study (Multiple case study) Qualitative methodology (case study method) Conceptual study (Theoretical framework) and Qualitative study (Multiple case study) Conceptual study and Qualitative study (Empirical study) Conceptual study (Theoretical framework) and Qualitative study (Multiple case study) Conceptual study and qualitative study (Multiple case study) Conceptual study and Simulation Conceptual study and Qualitative study (Multiple case study) Theoretical Study (Systematic Review—State of Art) Theoretical study (Framework model, analysis model) Theoretical study and Qualitative study (Multiple case study)



Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2015	18	Environmental Science & Policy, Transportation Research Part E: Logistics and Transportation Review (6), Ocean & Coastal Management (3), Human Ecology, Transportation Research Part D (2), Transportation Research Part C: Emerging Technologies, Journal of Cleaner Production, Environmental Modelling & Software, Transport and Environment, Global Environmental Change	Environmental Management (Key performance Indicators), Environmental Sustainability, Environmental Management, Environmental governance, Contractual mechanism, Organization mechanismCarbon emissions, Ship emissions, Sustainable Maritime transport, Fuel consumption, Decision support sustainability model, Sustainable Maritime shipping, Decision support systems (DSS), Multi-objective optimization (MOO) Environmental Management (TEAP) Significant Environmental Aspects (SEA), Environmental Management System (EMS) Air Pollution Management, Economic Sustainability, Supply chain sustainability, Multi criteria decision making, AHP Sustainable Development, Maritime Governance, Sustainable Shipping Environmental Management, Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA) Green shipping practice (GSP) AIS data, Cost externalities Green shipping, Port Emission Assessment, External costs and eco-efficiency parameters, AIS	Puig, Wooldridge, Michail, Darbra (2015) Lun, Lai, Wong, & Cheng (2015) Wong, Tai, Lau, & Raman (2015) Mansouri, Lee, & Aluko (2015) Puig, Wooldrige, Casal, Darbra (2015) Puente-Rodriguez, Swart, Middag, M., Van der Windt (2015) Maragkogianni, Papaefthimiou (2015) Lam (2015) Kavakeb, Nguyen, McGinley, Yang, Jenkinson, Murray (2015) Asgari, Hassani, Jones, & Nguye (2015) van Leeuwen (2015) Naser (2015) Lam & Lai (2015) Goldsworthy, & Goldsworthy (2015) Dragović, Tzannatos, Tselentis, Meštrović, & Škurić (2015) Lister, Poulsen, & Ponte (2015) Tichavska & Tovar (2015)	Theoretical study (review) and Qualitative Methodology (Multiple Case Study): Conceptual study and Qualitative study (Empirical analysis) Conceptual Study (Theoretical study) Conceptual study (theoretical study, Review Literature) Theoretical study (Conceptual study) Conceptual study and Qualitative study Conceptual study (Theoretical Framework) and qualitative study (Case study) Qualitative and quantitative methodology Conceptual study and Quantitative/qualitative study (Survey field/Multiple case study) Conceptual study (Theoretical study—State of Art) Qualitative study (Case study method) Conceptual study and Qualitative study (Case study methodology) Conceptual study and Qualitative study (Multi method approach)

Table 2. Cont.

Year	Art	Journal	Subtopic	Author(s)	Methodology
2016	9	Transportation Research Part D: Transport and Environment, Maritime Policy & Management, Environmental Science & Policy, Journal of Cleaner Production, Safety science, Environmental Science & Policy, International Journal of Sustainable Transportation, Atmospheric Chemistry and Physics, Marine Pollution Bulletin, Sustainability	Air Pollution Management, Fuel consumption, Environmental Management, Environmental Sustainability, Environmental performance, Sustainability performance Environmental performance Indicators (eKPIs) Environmental Management Systems, EMS, Ship Emissions, GHG Emissions, Ship Traffic Emission, Assessment Model (STEAM), AIS system, CO2 Emissions Synthetic indicators	Chang, Jhang (2016) Lu, Shang, & Lin (2016) Seguí, Puig, Quintieri, Wooldridge, & Darbra (2016) Hou, Geerlings (2016) Antão, Calderón, Puig, Michail, Wooldridge, Darbra (2016) Puente-Rodriguez, van Slobbe, Al, Lindenberg (2016) Papaefthimiou, Maragkogianni, Andriosopoulos (2016) Jalkanen, Johansson, & Kukkonen (2016) Laxe, Bermúdez, Palmero, & Novo-Corti (2016) Watanable & Tahora (2016)	Qualitative and quantitative methodology Conceptual study and Quantitative study [Survey field study—Structural equation model (SEM)] Conceptual study and quantitative study (Survey field study in inland ports) Conceptual framework and Qualitative study (Case study methodology) Review study and Qualitative study (Multi case study) Conceptual study and Qualitative study (Case study methodology): Conceptual study and Qualitative study (Cluster Analysis)
2017	24	Review of European, Comparative & International Environmental Law, Transport Policy, Marine Policy (2), Transportation Research Part D, The Online Journal of Science and Technology, Ocean & Coastal Management, Marine Pollution Bulletin (2), Transport Reviews, Business Strategy and the Environment Sustainability, Environmental Pollution Transportation Research Part D: Transport and Environment (4), Sustainability (4)	Air pollution Management Ship Traffic Emission Assessment Model (STEAM), GHG emissions, Energy Efficiency, Environmental Management (EMS), Environmental key performance Indicators (eKPIs), Environmental performance, Environmental management, (Waste management, Energy consumption and water quality), Carbon Management, Sustainability Development, Activity-based method, Air Quality, Bottom-up Approach CO2 reduction, Multi-level perspective, Ports emissions, Emissions Reduction,	Kopela (2017) Tichavska, Tovar, Gritsenko, Johansson, & Jalkanen (2017) Gritsenko (2017) Schenone et al., (2017) Kang & Kim (2017) Wang, Notteboom, Lau & Ng (2017) Styhre, Winnes, Black, Lee, Le-Griffin (2017) Tatar (2017) Puig, Pla, Seguí, Darbra (2017) Puig, Michail, Wooldridge, Darbra (2017) Tichavska, Tovar (2017) Carballo-Penela, Mateo-Mantecón, Alvarez, Castromán-Diz (2017) Nunes, Alvim-Ferraz, Martins, Sousa (2017) Bouman, Lindstad, Rialland, Strømman (2017) López-Aparicio, Tønnesen Thanh, Neilson (2017) Walsh, Mander, Larkin (2017) Pettit, Wells, Haider, & Abouarghoub (2017) Linder (2017) Roos & Neto (2017)	Conceptual study and Qualitative study Qualitative study (Multiple case study) Conceptual study (Theoretical paper) Theoretical study and qualitative study Conceptual study/Bottom-up approach Qualitative study (case study methodology) Quantitative and qualitative study (Factor Analysis) Conceptual study (Systematic Review) Conceptual study and Qualitative study (Case study methodology) Conceptual study and Quantitative study (Survey field study, Factor Analysis) Conceptual study and Qualitative study (secondary data analysis)

Many top-tier journals published these papers, mainly Maritime Policy & Management (7), Energy Policy (9), Ocean & Coastal Management (8), Business Strategy and the Environment (2), Sustainability (6), Research in Transportation Business & Management (4), Journal of Cleaner Production (6), Environmental Science & Policy (3), Marine Pollution Bulletin (8) and Marine Policy (5). This presence records a significant growth in the last five years, showing that this phenomenon in the port and shipping industry is becoming very important and receiving more attention by scholars and operators. The sample includes papers and journals mostly related to the management field in the port industry, and related to the shipping industry, according to the criteria adopted in the web search.

The search has outlined significant elements shown increasing attention by scholars on the issue, and more specifically, on the link existing between “environmental sustainability” and “port industry” which has become stronger over the years. Most publications are available in three journals: *Maritime Policy & Management*, *Energy Policy*, and *Transportation Research Part D: Transport and Environment*.

As shown from the results of the review, scholars adopt different reading lenses. Thus, the main studies on environmental issues in the seaport industry can be categorized into three perspectives: the technical, managerial and economic, and legal viewpoints. Furthermore, as shown in Table 2, most studies focus on subtopics such as “environmental sustainability” and “green port development” adopting the perspective of shipping lines more than port authorities.

Since 2010 the papers on this topic have started to increase in relation to the relevant innovative regulatory interventions at the international and European levels.

The main research subtopics investigated concern regarding water and air pollution, which are considered to be the major impacts of maritime and port activities [39]. Most of the issues analyzed involve both PAs and shipping lines (for example, water quality, air quality, waste management, energy consumption, oil spills, anti-fouling paints, and dust emission) [40–43] rather than those that are strictly linked to ports, such as noise or dredging [44].

In the previous literature on this topic, some scholars have tended to separate the study of environmental risks related to the seaport industry into two main categories [45]: (1) impact assessments and optimal solutions; and (2) environmental risk perception. However, to date, only a few environmental risk-based studies have focused on the impacts generated by port and shipping activities by adopting a mostly managerial and economic perspective [45]. This scarcity suggests the need to better clarify the phenomenon and systematize the contributions already existent in the literature.

Some studies adopt a technical viewpoint, focusing their attention on seeking and developing instruments aimed at reducing, for instance, gaseous emissions or emissions of particulate matter and carbon monoxide [46–48]. Other researchers attend to the managerial and economic perspective related to environmental sustainability [16,49–53]; for example, they examine the development and introduction of specific effective policies in measuring and controlling future cost scenarios for the reduction of CO<sub>2</sub> emissions by ships [51]. Finally, studies also pay attention to the main implications deriving from the regulatory system, especially from rules and norms at global and national levels that have introduced relevant limitations and behavioral obligations for port operators. Thus, in this case, scholars adopt a specific viewpoint that follows a legal perspective [21,54–56].

In more detail, first with reference to the technical perspective, several studies have investigated CO<sub>2</sub> emissions or other dangerous airborne emissions arising from international shipping [46,57–67]. Other studies have investigated carbon emissions per passenger-kilometer, as well as the burning of oil (especially heavy fuel oil and marine diesel oil) from international vessels regarding the emission of CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and hydrocarbons into the atmosphere [62,68–72].

Considering both technical and economic perspectives, the most significant and common approach has consisted of the “resource” approach (also known as the so-called “damage cost” approach). This approach estimates the opportunity costs related to damages occurring to natural resources or social welfare [45,73,74]. Another approach, the “prevention” approach, differs from other

techniques by focusing on estimating the damage costs and estimating the costs related to avoiding potential environmental impacts, especially impacts on global warming [73,74].

In this direction, and based on the INFRAS/IWW [73] study, the EU in 2005 introduced a new methodology in a research project named ExternE. This approach concentrated on external costs evaluation, such as from environmental impacts. The ExternE model was not developed specifically for the maritime transport sector, but it was designed for quantifying all the energy-related external costs from electricity and heat production as well as transportation [75,76].

Although these approaches have been useful for effectively measuring environmental costs in monetary terms, they are not able to be applied to all circumstances and countries, because they were developed through EU research projects, such as TRENDS [77], ExternE, and PETS and TRENEN [45].

Also, these approaches still lack in proposing and implementing managerial solutions in terms of managerial instruments for assessing, monitoring, measuring, controlling the processes related to environmental sustainability of ports and ships.

In addition, in the last ten years, several organizations composed of experts in the port and shipping industry have proposed tools to assess, monitor, and report on the performance of seaports, and the environmental impact derived from their activities and operations. Thus, with reference to the environmental sustainability of ports, the associations, such as ESPO (European Sea Ports Organization, Brussels, Belgium) and EcoPorts Foundation, have processed the “Port Environmental Review 2016” which is focused on redefining the environmental priorities of the European port sector. The report introduced the top10 of environmental priorities and provided for 2016 relevant insights and analyses. It is relevant to identify the most important priorities regarding the environmental issues on which ports are working and setting the framework for guidance and initiatives to be taken by ESPO and EcoPorts.

Moreover, the report presented key performance data on the environmental management of European ports for 2016. Establishing baseline figures, monitoring trends over time, and transparently reporting represent key elements able to give credibility to the European port sector and it is consistent with the environmental policy of ESPO.

The Port Environmental Review 2016 and the reporting on its outcomes took place in full cooperation and coordination between ESPO ([www.espo.be](http://www.espo.be)), EcoPorts ([www.ecoport.com](http://www.ecoport.com)) and PORTOPIA ([www.portopia.eu](http://www.portopia.eu)). In fact, the basis of reporting is fully in line with the environmental performance indicators that were developed in the PORTOPIA project. Furthermore, the results are also included in the PORTOPIA European Port Industry Sustainability Report for 2016 [78,79].

In this direction, 10 environmental management indicators—existence of an Environmental Management System (EMS), environmental policy, environmental policy makes reference to ESPO’s guideline documents, existence of an inventory of relevant environmental legislation, existence of an inventory of Significant Environmental Aspects (SEA), definition of objectives and targets for environmental improvement, existence of an environmental training program for port employees, existence of an environmental monitoring program, environmental responsibilities of key personnel are documented, and publication of a publicly available environmental report—are processed by PORTOPIA. These indicators provide information about the management efforts that influence the environmental performance of the port.

Besides, PORTOPIA has also developed the environmental monitoring indicators and the main indicators focus on the waste processes, energy consumption, water quality and water consumption, and air quality [10].

On the other hand, as Sara Blanco Monge (Systems Engineer at Isdefe, Madrid, Spain) explains, currently society is becoming more sensible about environmental protection, especially with reference to pollution that comes from the port activities and operations. See <http://www.greenport.com/news101/Projects-and-Initiatives/green-ports-initiative-in-spain> (access: 28 January 2018).

This concern might be confronted thanks to the adoption of a correct relationship between three factors: economic, social and environment. Indeed, according to Blanco Monge, to be competitive a

joint approach between the port and the rest of the authorities and companies is required by creating the conditions for sustainable development. Ports must be engaged in strategic thinking about their future.

The EU and the Commission, in particular, have been integrating such requirements into all their policies including transport. One of the goals is to ensure that modal “back-shift” from short-sea shipping to the road is avoided, or that the promotion of alternative fuel solutions in ports, such as the use of shore-side electricity, is encouraged. Generation and the use of renewable energies in ports are two more features mainly investigated in the literature. See: <http://www.greenport.com/news101/Projects-and-Initiatives/green-ports-initiative-in-spain> (access: 28 January 2018).

To provide and develop approaches and methodologies able to assess, monitor, measure, and control the environmental impacts of shipping activities in economic and monetary terms, Etkin [80] proposed a methodology to evaluate oil spill impacts from shipping activities. This methodology identifies and quantifies both natural environmental and socioeconomic losses, determines the damage and costs related to different spill types, and assesses all the necessary prevention and reduction measures [80].

Lately, other authors have proposed a set of economic evaluation models for assessing the environmental impacts due to accidental oil spills [81]. In their model, Liu and Wirtz [81] defined two main steps. The first one was related to the measure of lost services for a damaged natural resource and the second integrated the lost services with a unit value of the injured natural resource, where other economic evaluation methods were used to measure them. In this model, the main innovation was the “service recovery function” concept with a wider definition of “environmental impact cost”, including “natural environmental”, “social-economic”, “responding”, and “research” costs [81]. Both natural damages and economic losses summarized all the opportunity costs within the market.

Other scholars have introduced similar models but with their focus mostly on “economic losses” and “response costs” due to accidental (rather than routine) maritime pollution; these have adopted historically observed data analysis [82]. Still, others have analyzed environmental issues along the Israeli coastline, focusing on major polluting sources, like oil spills, that have an impact on natural ecosystems and economic resources [83,84].

Further studies used different models to assess small- and large-scale accidental oil spills, but these studies have missed other maritime pollution sources, and detailed evaluations of environmental impacts along coastal areas [83,85–87]. Otherwise, most researchers have paid attention to the environmental impact costs of pollutants mainly triggered by shipping disasters [73,88–92]. In these circumstances, ethical concerns regarding the risks and negative effects of maritime accidents need to be managed, by evaluating and implementing various assisting actions and policies such as clean-ups, impact assessments, and the enactment of various international, national, and local measures, such as the US Oil Pollution Act of 1990 (OPA-90) [93,94]. Finally, most studies, in defining the environmental impacts of the maritime and shipping industry, have focused only on natural damages, completely ignoring the economic losses for the coastline as well as the details about the environmental impacts of the maritime industry suggested by MARPOL 73/78/97.

In summary, numerous studies have introduced models and mechanisms aimed to estimate and assess the environmental impact within the maritime sector, paying more attention to the impacts of routine shipping operations [73,80,95]. However, they have exhibited similar deficiencies related to their geographic restrictions and their focus on large-scale accidental pollution [81,82,96,97]. Thus, most studies and reports still lack in proposing and developing specific effective managerial instruments for preventing and managing the environmental impact of port operations and activities with focus on processes.

In the context of this literature review, PAs play a key role among port players, as the main regulatory institution within seaports, because they need to take action aimed at protecting the environment, the global climate, local communities, and overall society by reducing and preventing the negative external effects of ports [5,7,8,98].

Consequently, PAs must manage port development by ensuring a balance between benefits and costs related to port activities, also assuming a “regulator function” for ensuring safety and security of ship and cargo operations within the port with respect to environmental and energy regulations and laws [99,100]. Otherwise, PAs receive continuous pressures in different ways [5] (pp. 291–292), that is: as a public institution, PAs must translate and apply national, regional, and global environmental regulations [99,101–104] and comply with all the regulations; ports need to consider the external costs of their operations and developments because of their effects, like port operations interruptions or port developments delay, as well as, effects on the community for the public and private financial resources received [105–109]; PAs aim to achieve high levels of competitiveness, as their main objective [110,111] but also they have to continuously and actively promote and implement environmental sustainability and green management practices [112–115]; since the 1980s, PAs assume and act as private firms [116].

In the general picture, port stakeholders (mainly PAs), must address, promote, support, provide and implement strategies and policies aimed at ensuring environmental sustainability. Hence, effective and efficient managerial instruments are required, on the one hand, for assessing, monitoring, measuring, and controlling the overall port operations and processes; on the other hand, for educating, training, and supporting all the actors in developing environmentally sustainable behaviors, as well as for guaranteeing compliance with all existing environmental and social regulations [112,117–119]. Thus, some previous studies already proposed managerial instruments in the port industry, such as BSC or TdB or training systems, but they do not have specific focus in using these instruments for addressing environmental sustainability.

## 5. Managerial Accounting Instruments and Training for Competitive Green Ports

The in-depth review of regulations and literature on environmental sustainability in the port industry allow us to document two main areas of deficiency.

First, the regulations and the existing research do not consider the accounting instruments, nor the general managerial instruments, that are able to make port stakeholders (especially PAs) act in an environmentally sustainable manner by assessing, monitoring, controlling, measuring, and reporting the operational processes concerning the transport flows of goods and passengers between sea and land for the competitive green ports. Second, even in a new scenario in which ports are oriented towards innovation management, the adoption of open data, Internet of Things (IoT), digital platforms, and regulations and previous studies are still limited in suggesting and developing effective training initiatives able to educate and guide human resources (mostly managers) within seaports for supporting the development of an awareness and behavioral attitudes towards accepting and playing an active role in environmental sustainability management innovation, in the direction of corporate social responsibility and ethical behaviors.

The PAs, to provide a strategic reply to the environmental legislative framework, should be supported by the managerial instruments creating an effective *trait d’union* between the port strategies, the port innovation management, and the human resource behaviors in the perspective of environmental sustainability. In other words, it becomes necessary to implement management practices, processes, structures, or techniques addressed towards port environmental management. The last organizational aspects identify the management innovation which, thanks to the introduction of effective managerial methods in the established organizations, activates a particular and interesting form of organizational change process [120,121], ([122] pp. 826–827).

Additionally, not all the stakeholders of port operations are involved in sustainable initiatives to the same degree because of their differing interests [123].

Some organizations, such as the Global Reporting Initiative (GRI)—an independent international organization which has promoted the sustainability reporting since 1997 and the sustainable operations transparency and stakeholder dialog. See for details: [www.globalreporting.org/information/aboutgri/Pages/default.aspx](http://www.globalreporting.org/information/aboutgri/Pages/default.aspx) (access: 27 January 2018)—deal with the port environmental sustainability issue by paying attention to the social corporate responsibility (SCR) and consequently, to environmental



sustainability reporting. Therefore, attention is paid to results and not to the environmental sustainability processes.

Following the management innovation perspective, this study provides a new reading of environmental sustainability phenomenon in the port industry to support the decision-making processes of the PAs by integrating managerial accounting instruments and training for developing green ports.

At this concern, management innovation becomes relevant because of its role and function. Indeed, management innovation consists of the invention and implementation of effective and innovative management practices, processes/structures, or techniques that constitute a significant departure from current norms, making an organizational change for enhancing firm performance [120–122,124]. Management innovation involves the introduction of novelty in an established organization, and as such it represents a particular form of organizational change [122] (pp. 826–827).

From the perspective of developing green ports, where ports need to be more environmentally aware and sustainable, the management innovation view may be crucial, because it concerns the introduction of new ways to follow and manage the deep organizational change process.

Within organizations in any economic settings, numerous innovative practices, processes, and structures are developed and adopted sometimes with success, and sometimes with failure. Green shipping practices (GSPs) can be conceived as management innovations with the purpose of reducing the adverse environmental impacts of shipping activities to achieve performance gains [125].

Effective practices such as managerial accounting are proposed to achieve a high performance from the management innovation perspective. For example, the managerial instrument BSC can combine financial and non-financial metrics as a single agenda item, making it possible to solve the problem to the satisfaction of all. Indeed, according to the environmental sustainability management innovation perspective, the BSC can be adopted for collecting and controlling information about the garbage (waste management) [126] (Annex V), and air quality practices of ships [126] (Annex VI) during the mooring and departure phases.

Success in the management innovation process requires a highly interactive environment [120–122]. Consequently, through specific educational tools and, especially, training at all organizational positions, changes within the workplace can be introduced and accepted by respecting the environmental sustainability issue.

Management innovation needs to be supported and spread within the culture and the entire organization. Indeed, following the cultural perspective of the management innovation model [121,122], it is possible to understand how management innovation shapes the model and how the organizational culture can support it. Four distinct perspectives on management innovation have been identified in the literature, that is, institutional, fashion, cultural, and rational) [122].

According to management innovation induced by a cultural perspective and linked to sustainability, this conceptual study points out the relevance of creating and stimulating an organizational culture, in which employees can think and feel that environmental sustainability is something related to their actions and behaviors, looking deeper into the problem and seeing innovative managerial ways and starting to hypothesize about effective ways of solving it. The workforce needs to be encouraged, supported, and guided through training to develop an awareness and involvement to foster sustainability management innovations, overcoming the limits of existing regulations. Management innovation changes the way workers behave; “management innovation changes how managers do what they do, but only if workers are completely involved, satisfied, and committed” [120] (pp. 73–75). The more the workforce is educated and trained regarding management innovation, the more that effective managerial practices will be accepted and successfully implemented for sustainability.

Following the management innovation vision, we aim to propose an integrated reading of both instruments, managerial accounting tools and training, for developing competitive green ports with focus on environmental sustainability.

### 5.1. Balanced Scorecard and Tableau de Bord for Environmental Sustainability Development within Ports

Over the years, several theoretical frameworks have been developed for measuring and controlling performance and for addressing organizational assets management. Among these theories and models, the most popular and applied frameworks are the BSC and the TdB [127–136]. These popular management frameworks rely on a better understanding of the drivers of value to aid managers in making decisions to improve corporate value creation [137].

The BSC was developed in the 1990s by Kaplan and Norton [127] and conceived as a multidimensional framework to describe, implement, and manage strategies at all organizational levels that strongly link objectives, initiatives, and measures to the firm strategy from a functional perspective. The BSC provides details regarding the possible results obtained from enterprise in terms of overall performance. According to some perspectives, the BSC supplements the financial measures provided by other key performance indicators (KPIs) such as financial, customer, internal business processes, and learning and organizational growth. More specifically, the financial perspective is about the profitability of the firm (that is financial indicators such as ROI, EVA and so forth); the customer perspective includes measures of successful outcomes in the direction of the firm's strategy (for example, customer satisfaction, customer retention and so forth); the internal business processes concern those processes that affect customer satisfaction and thus the achievement of the organization's financial objectives; and learning and growth (or innovation and learning perspective) includes the innovation issue, measuring continuous improvements for existing products and processes, as well as the launch of new products. This last perspective can also identify the fundamentals needed for building and managing long-term growth and competitive advantage in the organization through people, systems, and procedures. In each perspective, it is possible to identify sets of singular indicators with the function of dashboards. These sets provide knowledge factors that support monitoring processes for the business strategy. Hence, Abran and Buglione [138] (p. 342) argue that “knowing the causal relationships across the indicators, the business executives must then, each time, figure out a consolidated assessment of current organizational performance”.

On the one side, the BSC allows the search for solutions to support the implementation process for the strategy [127,139–141]. On the other side, because of the nature of the BSC—the adoption of a hierarchical top-down model—this strategic managerial tool is open to criticisms and limits [142].

Kaplan and Norton [143] (p. 31) identify some relationships characterized by cause and effect variables: first, measures of organizational learning and growth imply the measures of internal business processes, which implies measures of the customer perspective, and finally implies financial measures. According to Kaplan and Norton [143] (p. 30) the strategy is a set of hypotheses based on these relationships. Thus, the BSC is a strategic measurement system but also a strategic control system adopted by public and private entities.

Otherwise, the BSC might be considered an effective tool for making decisions addressing cost reduction and environmental performance improvement, and also for increasing the level of knowledge to carry out the processes by port players (especially PAs), who tend to behave similarly to private firms. According to Agostino and Arnaboldi [144] (pp. 332–333), two main reasons can justify the adoption of the BSC. These are the increased attention paid to this tool by top and operational managers, and the specific characteristics that make it concise and succinct, thanks to the development of adequate key performance indicators (KPIs).

Therefore, the BSC might represent a useful tool for justifying top-down control [145] (p. 612). Crucial factors for the BSC are the measures and performance drivers of outcomes, connected together following a cause-and-effect relationship [127,128]. However, a cause-and-effect relationship between some of the suggested measurement areas does not always exist. For instance, Kaplan and Norton [127,128] argue that the cause-and-effect relationship between customer satisfaction and loyalty, and between loyalty and financial results, is still missing.

For example, the Port Authority of Valencia (PAV) adopted the BSC as a strategic management instrument for three reasons: the first reason was the need to improve its strategic planning process,

the allocation of resources and its strategic follow-up system; the second reason was the willingness to reinforce its organizational management culture; finally, the third reason was to strengthen the role of the PAV as the promoter and leader of the port community, by using the BSC as a system to communicate its common strategy and promote teamwork among the members of the port community [146].

Another case of a port authority that implemented the BSC is the Port of Aveiro. This represents an interesting case study since the port authority is operating in a unique business network environment. This is a case that shows that the BSC helps to deal with the high complexity of performance measurement inside mixed-type networks because the traditional performance measurement tools of ports focus only on financial performance. Mixed-type networks however also require the tracking of non-financial measures. In fact, these might be more important for developing and implementing the strategy than more traditional financial measures. The BSC allows members of complex business networks to strike a more balanced perspective between financial and non-financial performance [147].

The concept of the BSC, compared to the TdB, came from the realization that no single performance indicator could capture the full complexity of an organization's performance. In particular, financial indicators have well-known weaknesses, such as capturing the impact of decisions with a significant time lag. Consequently, they tend to be less proactive indicators of potential problems than operational (non-financial) indicators. For more than fifty years, the TdB has been used in France within firms for assessing, monitoring, and measuring their performance by considering organizational processes [129]. The TdB represents a dashboard such as an instrument used by "plane pilots and car drivers to observe the speed at which they are going, how many miles they have covered so far, and how much fuel they are consuming" [130] (p. 4).

At the beginning, this instrument was developed by process engineers who searched for ways to improve their production process by better understanding cause-effect relationships (relationships between actions and process performances) [133,136]. Later, top management within businesses applied the same principle by giving senior managers a set of indicators to monitor the progress of the business, comparing it to the goals that had been set, and taking corrective actions. Two important implications can be distinguished that are linked to this succinct overview of key parameters to support managers' decision-making processes [130] (pp. 4–5). First, the TdB cannot be a single document applied equally well to the whole firm, because each sub-unit, and in fact each manager, has different responsibilities and objectives. There should be one TdB for each sub-unit and these "dashboards" should be integrated in a nested structure. In each context, the firm's overall TdB would translate into a series of documents supporting local processes. Secondly, the various TdB used within the firm should not be limited to financial indicators. Operational measures often give better information on the impact of "local" events and decisions and thus on cause-effect relationships than overall financial indicators.

In summary, the TdB needs to be personalized and contextualized for each manager and sub-unit. It needs to be developed in the context of the mission and objectives of each unit. Due to the need to develop the TdB for each manager and sub-unit, it is necessary to translate the unit's vision and mission into a set of objectives from which the unit identifies its key success factors (KSF), which would then get translated into a series of KPIs. Thanks to the TdB, managers can use information for their decision-making processes. In fact, it should primarily contain performance indicators that are largely "controllable" by the sub-unit. "Concretely, TdB documents should report actual performance of the (sub-)unit on a small number of indicators; conciseness is important and the danger of overloading managers with information is often highlighted by French authors" [130] (pp. 3–4).

Overall, the TdB documents present some relevant benefits. They can provide each manager with crucial information and act as a guide for his/her decision-making processes with a periodic succinct overview of the performance of its unit. The TdB also constitutes a useful instrument that informs the next level up of the sub-unit is performance (a complement to decentralization of responsibilities).

The TdB has some similarities with the much more recent BSC concept, as well as some differences. First, for example, the TdB concept has a stronger focus on controlling the operative business process system. In addition, standard procedures for implementing TdB systems at companies have been formulated explicitly [133]. Indeed, the BSC shows that no single performance indicator allows capture of the full complexity of organizations' performance. In particular, well-known limitations and criticisms have been associated with financial indicators, such as capturing the impact of decisions with a significant time lag. As a result, financial indicators, compared to operational (non-financial) indicators, tend to be less proactive indicators regarding the opportunity to prevent potential problems [129,130,137].

In the overall market and, hence, also in the port industry, "sustainable development requires sustainability innovation and entrepreneurs who can achieve environmental or social goals with superior products or processes that are successful in the marketplace of mainstream customers" [148]. Organizational innovation usually does not occur spontaneously, nor does it necessarily occur by accident. However, it is necessary that it is created by managers and the overall company, and that it becomes part of the core of the business activities.

The TdB lends itself to better measure human capital. This tool does not imply a link between strategy and measurement. This dashboard complements the measures used by the BSC (the link between strategy and performance) in the perspective of innovation and training. Both tools can be used in public administration, such as for ports [149].

In other words, the TdB allows for the inclusion of some performance measures that are not linked to the PAs' strategies but only to the operational processes. This instrument can be used by PAs to integrate the information obtained by using the BSC in the management innovation perspective. Moreover, it is possible to implement, on the one side, the TdB and, on the other side, the BSC. Both can be adopted as management innovation tools, as well as joining innovation management tools such as digital platforms, IoT and so forth.

In this direction, any organizations that can make environmental progress a core aspect of their business can be called sustainable entrepreneurs, including ports. Otherwise, "managers can make a significant contribution to both the company and society" [137] (p. 587), but they need to be supported by effective tools for improving their performance in environmental sustainable development.

The use of both managerial instruments—the BSC and the TdB—an help to identify a strategy for environmental sustainability in the port industry, which allows defining of effective and efficient solutions especially for PAs. This would also fill the still-existing gap in the regulatory systems and the literature about the definition and implementation of managerial accounting tools for environmental performance. Thanks to these instruments, the port players (especially PAs) can prevent and manage, for example, the negative effects related to the activities and operations performed by PAs and shipping lines regarding specific perspectives addressed to guarantee the efficiency and effectiveness processing.

We focus on both managerial instruments, because although as shown in previous studies, they are already adopted in the port industry, we observe that their implementation is still missing in the environmental sustainability orientation, and also because they are considered separately. Instead, we consider an integrated use of both managerial instruments, where, on the one hand, the TdB allows management of the human capital issue independently by the strategies by collecting useful information about intangible resources needed to be oriented through sustainability training, and on the other hand, the BSC allows analysis of the organizational processes with a direct link to the strategies, also through the development of effective indicators for assessing, monitoring, measuring, controlling, and reporting the organizational processes implemented by PAs following the sustainability strategies adopted.

## 5.2. Training for Environmental Sustainability Development within Ports

The greatest challenge faced by port stakeholders (various players such as carriers, shippers, transport operators, regulatory institutions, etc.) in implementing environmental sustainability

performance is regarding the involvement of workers at all organizational levels. That is, how to empower workers and make them more aware of adopting strategies and policies and performing tasks that respect environmental sustainability.

Some specific measures have been suggested and recognized as useful and effective solutions such as “efficiency targets and standards, benchmarking, energy audits, and energy management requirements, complemented by training, capacity-building, information provision and awareness raising campaigns” [150] (p. 936). At the same time, in the PORTOPIA Sustainability Report 2017, among the environmental management indicators used for evaluating the environmental aware and sustainable behavior of ports, there was one specific question regarding the “existence of an environmental ‘training’ for port employees” [13–15], that showed the crucial role played by training in this area to address environmental sustainability within ports. Training, specifically “environmental training” has been recognized as effective managerial practice with an important function and resource for responding to the increasing pressures of environmental sustainability of ports [151].

In environmental management research, two main correlated steps are necessary: (1) to study the workforce (human resource) management; and (2) to activate training programs for them [152–156]. However, although this topic is relevant, it is still understudied [157–161]. Indeed, most research on environmental operations management addresses to identify and explore mid-level (firm/supply chain) issues and questions [151]. However, the workforce issues and environmental tools receive much less attention. Researchers need to focus and understand the dynamics within organizations, that is, the impact of environmental pressures on the workforce, its values, and its behaviors. Thus, one important issue is the workforce training requirements for promoting and adopting effective environmental tools starting from the micro level of organizational structure, for example, redesigning the work model for the environment, conducting life-cycle analysis, recycling or other environmentally proactive practices to adopt within the heart of organizations [152], for instance to implement the BSC or TdB.

Unfortunately, most people still tend not to pay attention to the effects of their behaviors. They tend not to see or feel the link between their actions and the general environmental sustainability performance and the environmental impact of their actions [162]. Thus, most port players, workers, and organizations in the port and shipping industry are not willing to take the risk associated with environmental sustainability issues. Consequently “port workers should be aware of environment and maritime safety through training” [163] (p. 193). In this direction, ports combine a set of measures, awareness training, and tougher regulations to bridge the existing gap between environmental aspirations and practice. For instance, as advised by the EU (Directive EC85/337, later EC97/11), ports can conduct environmental audits which, although not mandatory, make the port managers punitively liable for environmental damages [164].

The numerous barriers still existing in adopting and implementing various environmental practices can be significantly overcome thanks to training, specifically “environmental training” [151–156]. These barriers consist of not only technical obstacles but also mostly include organizational culture and change management barriers [165].

Training programs, focused on educating and increasing knowledge for employees, can help to overcome these barriers because, in this way, thanks “to this new knowledge, employees can really understand how the environment can affect and be affected by their duties and decisions and behaviors” [151] (p. 165).

With the aim of conserving and enhancing environmental sustainability, staff education and training are required and become necessary for guiding human activities through an environmental code of practice. For instance, PAs provide waste reception facilities and adequate measures are taken, such as a concrete Environmental Management System (EMS), which consists of a set of internal policies, assessments, plans, and implementation actions for the entire organization with a focus on the effects on its relationships with the natural environment [166–168]. An EMS can support the organization respecting legislation and regulations notified by trade associations (including EcoPorts)



and government bodies. Training represents a key factor in implementing EMSs thanks to its influence on the attitudes and behaviors among managers and employees [169]. Sustainability and specifically environmental training for staff can have significant benefits: “to encourage personnel to join trade associations, attend conferences or visit other ports to share best practice; to make a mission in educating and training port players to be aware of their impact on the environment; to engage specialist training providers; to plan and implement procedure, especially for archiving records, for example AIS (Automatic Identification System) records of anchoring operations and incidents arising during bunkering operations” [164].

Likewise, thanks to sustainability (specifically environmental) education and training, workers improve their perception of organizational commitment and pay more attention to the environmental issue. Employees with a strong commitment to the environment are also more creative in suggesting solutions to advance sustainability [157].

Additionally, education and training for sustainability management are gradually becoming a relevant part in courses within business schools of European and American universities [170,171]. Scholars tend to pay increasingly focus on “ill health associated with air and water pollution”, “pollution prevention”, and “waste management” [171].

Educational promotion and vocational training, using different initiatives such as brainstorming techniques during work meetings, specific tutoring or mentoring programs, and learning by doing (analysis and implementation of environmental principles), play a crucial role for the port and shipping industry because they represent concrete facilitation in preventing environmental pollution and in improving environmental management systems in general [172].

The main limitations observed in interpreting the regulations and the literature on environmental sustainability concern the liability of port players in stimulating deep changes in the organizational culture and climate. Thus, in turn, it is necessary to promote more awareness of environmentally sustainable behaviors, and training and educating the workforce to face and manage this challenging issue.

Otherwise, the criticisms related to the adoption of regulations on environmental sustainability, are widespread in the shipping industry with high level of environmental risks.

On the one hand, port players tend to quantitatively respect existing regulations (for example, on the required and imposed limits for air or water pollution from port operations), but there is no qualitatively effective involvement and active participation of staff (including all shipping workers), in thinking and acting with complete respect of environmental sustainability principles. Workers do not really participate in the organizational processes, feeling and thinking in the direction of environmental sustainability. On the other hand, organizations that apply the existing regulations do not effectively support and apply the regulations on environmental sustainability with adequate initiatives or practices that are able to stimulate changes in the organizational culture and provide an actual awareness of environmental sustainability at the workplace in adopting a more global vision.

Through our analysis, we have found that the overall regulations, codes, and guidelines on environmental issues represent the global legislative systems of rules and conditions that all port stakeholders, including PAs, and shipping lines must respect. However, at the same time, they need to develop and adopt specific managerial tools to make both effective and efficient decision-making processes: above all in terms of reducing negative external costs for the environment and adequate training initiatives for developing ethical and social responsibility behaviors. According to the EMS perspective [166,167], port players need to invest in training their employees to improve the organization’s environmental management and continually assess their processes for avoiding inefficiencies. Thanks to training, workers are encouraged to work together in teams and continually improve the organization’s environmental performance [155]. Otherwise, training can be conceived as complementary to managerial accounting tools, specifically the BSC and TdB. Indeed, the BSC and TdB were traditionally “developed to translate strategies that were aimed at maximizing shareholder value by gauging economic performance only” [134] (p. 463). The social or environmental dimensions



were completely ignored. However, in recent years this traditional vision has significantly changed, recognizing that more relevance to social and environmental issues and, in this case, training is critical.

## 6. Concluding Remarks and Future Perspectives

This conceptual study focused on the issue of environmental sustainability and drew from the regulatory systems and from the main studies in the literature on the topic of the management innovation perspective. We observed and described the implications of regulatory systems for port players, especially PAs, in terms of obligations and liabilities. Next, we outlined the still-existing gap both in the regulatory frameworks and in the literature because no specific managerial accounting tools and training interventions are suggested to achieve higher environmental performance, especially with an integrative reading, from the perspective of competitive green ports making possible management innovations.

Although regulations (EMS types and international norms) and numerous past studies on environmental sustainability issues show the relevance in adopting managerial accounting instruments and promoting training for port employees, this aspect is still under-researched.

Regulations do not provide specific suggestions to port players about which effective managerial tools they can adopt to guarantee environmental protection in performing their functions and activities, as well as how they can educate and train the workforce in achieving sustainability goals. Starting from this gap, according to the management innovation approach, we investigated the phenomenon and proposed an integrated reading of managerial accounting tools and training, showing that port players, mainly PAs, need to develop and implement both elements to achieve high environmental sustainability performance.

In the port industry the effective implementation of instruments requires managerial involvement in the design process, and also, the various players within the port industry need to be involved in the environmental legislation process through consultation, agreements about specific guidelines and best practice, and developing benchmarks, management schemes, training, monitoring, research, and collaborative solutions [164].

This study aimed to open the mind of organizations within the port industry through the development and adoption of an integrated approach, where managerial accounting tools—the BSC and TdB—and training initiatives can be read, developed, and implemented together. This makes it possible for employees to participate actively and effectively in finding ways to think and act on environmental sustainability without perceiving the related regulations as a single obligation, and enabling the use of management innovations.

In the next steps, we aim to propose specific environmental KPIs, indexes able to know, manage, assess, measure, monitor, and control the decision-making process of port stakeholders, focusing on PAs, as one of the main regulatory institutions within seaports. In addition, considering this study only a starting point of our research, whose contribution consists of a conceptual management proposal, which still lacks a validation in terms of its effectiveness in practice, the future development of our study will focus on specific experiences in seaports according to the sustainability management innovation perspective.

Despite some limitations of our paper, especially because of its conceptual nature, we can outline some interesting contributions. Indeed, in recent decades the increasing attention paid to environmental issues in the port industry has mainly addressed the investigation of topics such as the control and measurement instruments of the impact on the territory of port players' performance or the definition of the geographical routes that are more environmentally sustainable. Thus, it could be useful and interesting to define and develop a broad research design identifying specific key variables that have a significant impact on green port performance and, also, pay more attention to the human factor through environmental training.

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