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GREEN STRATEGIES OF PORT MANAGING BODIES: EMPIRICAL EVIDENCE OF STAKEHOLDER PRIORITISATION IN ITALIAN PORTS

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Abstract

Port managing bodies (PMBs) are in the front row for reducing the environmental impact of maritime logistics activities and supporting the decarbonisation of the whole industry. They are expected to act as principal performers, or orchestrators, of green strategies (GSs) and meet the increasing requirements of the main port stakeholder groups (PSGs). According to the corporate social responsibility (CSR) principle, a new sustainable approach to port management has been introduced to consider PSGs objectives in the planning process and face the challenges of climate change. However, CSR can contribute substantially to the overall port performance only when PMBs identify critical PSGs and carry out specific GSs to meet their expectations. Although GSs are an emerging topic, no prior contributions have theoretically and empirically investigated stakeholder prioritisation practices of PMBs when designing and implementing GSs. Therefore, the paper contributes to the academic debate on sustainability in the port domain providing an overarching taxonomy of GSs. It also aims to estimate the stakeholder prioritisation for GSs through an indirect methodological approach that is empirically applied on four Italian PMBs. The findings stress multiple objectives of GSs consistent with the CSR perspective and trace the trends of green initiatives in the Italian ports to meet the diverse PSGs' expectations. Port managers can also benefit from the implication of the study to improve the decision-making process concerning GSs.

Keywords: green strategy; CSR; port managing bodies; stakeholder prioritisation; sustainability; Italian ports

1. Introduction

Around 80% of global trade by volume is carried by sea that makes shipping the backbone of the global economy (UNCTAD, 2020). Although shipping is widely considered relatively greener than other transport modes, such as aviation or road transport, it is responsible for 2.9% of global anthropogenic greenhouse gas (GHG) emissions according to the 4th IMO GHG study (2020). Recent figures also show the shipping industry releases 1.2 to 1.6 million tonnes of PM10, 4.7 to 6.5 million tonnes of SO_x, and 5 to 6.9 million tonnes of NO_x worldwide (Nunes et al., 2017). Several studies have demonstrated the effects on the air quality are much more significant in coastal areas than in the open sea (Gilbert et al., 2018). Indeed, most of the environmental impacts are caused by day-by-day port activities when the ships are at the berth (Becker et al., 2018). Nunes et al. (2017) argue at least 70% of ship emissions occur within 400 km of the coast having severe consequences for local communities of maritime cities. Negative externalities also originate from the magnitude of highly impacting business processes embedded in the port area, including cargo handling, bunkering operations, waste management, and dredging (Dinwoodie el at., 2012; López-Navarro et al., 2015; Alamoush et al., 2021). The port industry represents an energy-intensive sector that can generate environmental impacts in several matters (Bailey and Solomon, 2004).

Given their prominent role within the maritime logistics ecosystem (Van der Lugt et al., 2013; Castellano et al., 2020), port managing bodies (PMBs) are also in the front row for reducing the environmental impact of the maritime logistics activities and promoting the decarbonisation of the whole industry (Hiranandani, 2014; Bergqvist and Monios, 2019). As regulators, PMBs are called to implement international, regional, and local environmental regulations and policies as well as monitor and guarantee their compliance by carriers, terminal operators, and port users (Poulsen et al., 2018). Moreover, they are expected to act as principal performers, orchestrators, or, at least, promoters of green strategies (GSs) (Kang and Kim, 2017; Martínez-Moya et al., 2019). This is a "*sine qua non*" condition to achieve the targets set by policymakers, address the implications of climate change, and obtain the licence to operate from port stakeholder groups (PSGs). Indeed, several studies argue PSGs have become aware of environmental emergencies related to the maritime logistics industry and they are exercising a greater pressure on port management for greener and more sustainable solutions (Le et al., 2014; Acciaro, 2015; López-Navarro et al., 2015; Chen and Lam, 2018; Stein and Acciaro, 2020). Consequently, since the 2000s corporate social responsibility (CSR) aspects have entered the planning activities of PMBs (Dooms et al., 2013).

CSR reflects the obligations and responsibilities that an organisation should have for its stakeholders and the broader social good (Matten and Moon, 2008). In this perspective, a new sustainable approach to port management has been introduced to consider PSGs objectives in the decision-making process and strengthen the environmental sustainability in the maritime logistics industry in both public and private entities (Puente-Rodríguez et al., 2016; Castellano et al., 2020). This is not only a legal requirement and/or an ethical commitment, but also a strategy to improve port reputation, stakeholder management practices, and, thus, port competitiveness (Notteboom et al., 2015). Indeed, GSs enable PMBs to meet the requests of multiple PSGs and achieve different CSR objectives, including economic, market, governance, regulatory, and social that are complementary to the environmental ones (Acciaro, 2015; Ashrafi et al., 2020; Castellano et al., 2020). However, CSR can contribute substantially to the overall port performance only when critical PSGs are identified and specific GSs are carried out to meet their expectations (Dooms, 2019). Therefore, the identification and prioritisation of the salient critical stakeholders still constitute a crucial issue in port management.

Although GSs are an emerging topic, no prior contributions have theoretically and empirically investigated stakeholder prioritisation practices of PMBs when designing and implementing GSs. Moreover, a taxonomy of GSs urges both scholars and practitioners to deeper understand the environmental benefits of these CSR interventions and related beneficiary PSGs. The identification of salient beneficiary PSGs of GSs may support port managers when dealing with strategic decision-making and may allow to improve CSR strategies.

Given the gap in academic literature, the paper aims to answer the following two research questions (RQ):

- **RQ1**: Which are the main typologies of GS performed by PMB and the related CSR objectives?

- **RQ2**: Which are the salient beneficiary PSGs of GSs performed by PMB?

The remainder of this paper is organised as follows. Section 2 introduces GSs and CSR in the port domain. Section 3 proposes a conceptual framework to examine GSs according to the CSR and the stakeholder relationship management (SRM) perspectives. The methodological approach is described in Section 4 along with case-studies selection and data gathering. Section 5 reports and discusses the findings related to a sample of four Italian PMBs significantly involved in GSs. Finally, the implication for academics and port managers are reported in Section 6.

2. Green strategies and corporate social responsibility in port managing bodies

In the next years, major ports worldwide are expected to face different environmental challenges related to climate change adaptation and mitigation, reduction of harmful emissions from maritime logistics activities, and compliancy to more stringent environmental regulation (Becker et al., 2018; Poulsen et al., 2018; Castellano et al. 2020; Alamoush et al., 2021). In this vein, the introduction of the "green" perspective in port management and development plans is enabling PMBs to foster port sustainable growth and meet the expectations of multiple stakeholders (Bergqvist and Monios, 2019).

Previous academic studies have explored GSs in the port domain by adopting different perspectives, including managerial (Acciaro et al., 2014; Lam and Notteboom, 2014; Di Vaio and Varriale, 2018), operational (Dinwoodie et al., 2012; Puig et al., 2020), technical/technological (Davarzani et al., 2016; Martínez-Moya et al., 2019; Sdoukopoulos et al., 2019), and normative (Poulsen et al., 2018; Schrobback and Meath, 2020; Alamoush et al., 2021). A strong link with the concept and principles of CSR emerges from the literature since the environmental objectives of GSs are often extended by academics to other port management spheres, especially for managing PSGs (Dooms, 2019). Table 1 summarises the six principal CSR-related objectives of GSs according to the prominent academic contributions.

TABLE 1

However, the implementation of a CSR may face many obstacles and barriers, especially when it comes to GSs (Dooms, 2019). One of the most challenging issues is to identify and prioritise deserving stakeholders among the myriad of groups and individuals with a stake or an interest in the business (Mitchell et al., 1997). This is particularly the case of the maritime logistics industry where PMBs are called to harmonise strategic objectives with the claims and interests of many different PSGs (Acciaro, 2015). Dooms (2019) states PMBs should identify, classify, and prioritise salient stakeholders before planning specific sustainability strategies to avoid wasting resources and achieve the expected outcomes. The recognition of stakeholder salience requires well-defined criteria to evaluate the influence of each PSG on port processes, operations, and performance. However, this procedure typically suffers from different limitations and bias arising from "politically correct" behaviours and assessment of PMBs (Notteboom et al., 2015). Indeed, port managers may prioritise specific PSGs because of the predominantly public nature of PMBs that generally do not perform corporate behaviours. While some PMBs are moving towards more independent management structures and commercial approaches as private entities, most PMBs worldwide are still government-owned or state-owned enterprises that prioritise strategic objectives for the public good than for being competitive in the market (Van Der Lugt et al., 2013).

Given the heterogeneity and complexity of PSGs' interests (Le et al., 2014; Ashrafi et al., 2020), no prior studies have investigated the stakeholder prioritisation process for GSs according to the perspective of PMBs. This process requires greater attention by academics to feed the international debate on CSR in the port domain

and support port managers in complex strategic decisions. Therefore, the paper aims to fill this gap by providing a conceptual framework and an empirical approach to deepen knowledge on this matter.

3. Conceptual framework

The paper applies the CSR and stakeholder relationship management principles to develop a conceptual framework for exploring GSs in ports and identifying related salient beneficiary PSGs as reported in Figure 1.

FIGURE 1

To answer the two research questions of the study, the conceptual framework emphasises the complementary effects of environmental interventions to economic, market, governance, regulatory, and social objectives. Moreover, it reports two different approaches (i.e., direct and indirect approach) to identify the salient PSGs of GSs according to stakeholder management theory and the pioneering work of Notteboom et al. (2015). In the direct approach, PMBs are expected to "weigh up" PSGs according to their strategic objectives, to estimate the benefits arising from potential GSs for each PSG, and, finally, select those GSs that generate greater benefits for the salient PSGs. However, the direct approach typically suffers from inherent limitations and bias due to the predominantly public nature of PMBs. This results in major attention towards specific PSGs because of "politically correct" attitudes and behaviours that do not reflect the real strategic goals of PMBs.

Given the above, Notteboom et al. (2015), the Authors propose the indirect approach for evaluating how PMBs prioritise the PSGs through GSs. The proposed methodology relies on an empirical approach starting from the inductive identification and classification of the main typologies of GSs performed by selected PMBs. Then, it evaluates the environmental benefits of each GS and related CSR spillovers consistent with the social, economic, market, regulatory and governance objectives. As each GS generate diverse benefits, it is possible to score the relevance of each typology of intervention for the different PSGs. This results in a GSs/PSGs matrix that highlights the salient beneficiary PSGs of each GS. Finally, the combination of the outcomes arising from these two empirical phases enables an indirect estimation of stakeholder prioritisation by PMBs when developing effective GSs.

In summary, the indirect approach is an empirical methodology that requires the three steps described in the following Section 4: i) identification and classification of GSs; ii) scoring the salient beneficiary PSGs of GSs; and iii) estimating stakeholder prioritisation for GSs. These methodological steps are preceded by case studies selection that draws the empirical background to test the conceptual framework.

4. Methodology

4.1. Case studies selection

The conceptual framework grounds on the European regulatory and institutional setting and, specifically, is empirically applied to the Italian ports. The Italian case has been selected due to several reasons.

From an economic perspective, Italian ports are located on important traffic routes with very high volumes of cargo and passengers. In 2019, the Italian port system recorded a cargo volume of 479 million tons and 56 million passenger traffic (Eurostat, 2020). It is also the leader in the Mediterranean for short sea shipping with a 39% market share and ranked first in Europe for the number of cruise passengers (Brewer, 2020).

From an environmental perspective, the maritime logistics industry is one of the main sources of environmental pressure in Italy because it contributes to both air pollution and GHG emissions. According to Brewer (2020), during the period 2000-2017, Italy's national average PM2.5 levels were between 20% and 30% above the EU average and consistently higher than levels in other large European countries. In this context, the transport sector has become responsible for over 24% of total GHG emissions in 2019 (European Commission, 2020). The environmental externalities of the maritime logistics industry are even more urgent in Italy because of the 7.600 km of coastline (one of the top twenty countries in the world in terms of coastline length) and one-third of the Italian population living within 5 km of the coast (Brewer, 2020). As a member of the European Union, Italy must respect the targets set by the European Commission to reduce pollutants (e.g., the strategy 2018/773/EC). Complying with EU directives requires PMBs to adopt GSs, but there is very limited evidence on the green attitude of Italian ports.

However, the Italian legal and institutional framework has recently evolved. In 2016, the reform of the Italian port system introduced significant changes both in the administrative organisation and management of port areas. The Port System Environmental and Energy Plan (DEASP) was introduced, making the elaboration of this document compulsory for each Italian PMB. The DEASP examines the current and future port's energy demand and provides the main GSs to reduce the environmental impact of maritime logistics activities. Although the Italian PMBs have taken several steps to become more sustainable, GSs vary widely in terms of the type of initiatives and geographical coverage. This urges further examination.

For the aim of the study, four Italian PMBs are selected (i.e., Western Ligurian Sea Port Authority, Eastern Ligurian Sea Port Authority, North Tyrrhenian Sea Port Authority, and Sardinia Sea Port Authority) that are accounted for 36% of goods and 32% of passengers transported in the country in 2019 (Assoporti, 2019). After the Italian governance reform in 2016, they have been managing a total of 19 ports including the core Trans-European Transport Network (TEN-T) ports of Genoa, La Spezia, Livorno, and Cagliari. According to the respective DEASP, all these PMBs are strongly committed to GSs, and they are participating in several European projects with local and international partners for the reduction of the environmental impact of the industry. Appendix A summarises the key figures of selected case studies as well as their commitment to GS.

4.2. Identifying and classifying green strategies: a taxonomy.

The first step of the proposed indirect methodological approach is the identification and classification of GSs. First, the Authors have performed desk research by scrutinising the Port System Environmental and Energy Plan (DEASP), Strategic Planning Document of Port System (DPSS), and additional strategic planning documents and reports on environmental and energy management released by selected Italian PMBs. Second, in-depth interviews with the port managers of selected PMBs were conducted to broaden the sample and further investigate the environmental benefits originating from GSs. The Authors organised four separate meetings: two in presence with the director of the Environment, Plant and Maintenance Service department of Western and Ligurian Sea Port Authority and the head of Special Projects, Innovation and Institutional Relations of the Eastern Ligurian Sea Port Authority; and two online with a manager from the Planning and Development Department of Sardinian Sea Port Authority and with a manager from the Development and Innovation department of North Tyrrhenian Sea Port Authority. The in-depth interviews were divided into two parts: the first addresses the PMB's CSR strategy and related GSs to meet stakeholders' expectations; the second aims to deepen knowledge on the environmental benefits achieved or expected from each GSs.

After the systematic analysis and review of all the relevant documents gathered from desk research and interviews with key informed PMBs' personnel, a database of 81 GSs (i.e., statistical units) was developed. The breakdown of the GSs per sample PMBs are reported in Table 2. The database reports the project title, description, timeframe period, budget, and principal environmental benefits of each GS (See Appendices B, C, D, and E).

Then, two classification schemes were used to systematically organise and classify GSs: GS typology and GS objective. The typologies of GSs were inductively established from the documents under examination, employing an iterative process of category building, testing, and revising by constantly comparing data and

information available. The final set consists of 8 comprehensive and consistent categories (Table 3), resulting from a review process that involved all the Authors. Moreover, a short survey was sent to academic colleagues and the port managers previously interviewed to validate the selected categories.

TABLE 2

The second classification scheme is based on the 5 categories of CSR-related objectives (i.e., economic, market, governance, regulatory, and social) that can be pursued by PMBs when performing GSs along with environmental ones. As reported in the conceptual framework (i.e., Section 3), these categories were deductively determined from the CSR literature on port management.

TABLE 3

4.3. Evaluation of the salient beneficiary port stakeholder groups of green strategies

According to the definition of stakeholder by Freeman (1984), port stakeholders can be identified as an individual or group holding a legitimate interest in or being affected by port action or inaction (Notteboom and Winkelmans, 2003). This wide definition leaves room for different interpretations and diverse classifications of salient stakeholders (i.e., those who can contribute to achieving port objectives). Consistent with prominent academic contributions (e.g., Notteboom and Winkelmans 2003; Notteboom, et al., 2015; Ashrafi et al., 2020), this study identifies 10 groups of port stakeholders that are summarised in Table 4.

TABLE 4

To score the salient beneficiary PSGs of GSs (i.e., the second step of the indirect approach), the Authors administered a structured questionnaire to a panel of international experts with a strong background in the maritime logistics domain through the online platform Survey Monkey. The questionnaire was sent to 75 experts and remained open from 18 October 2021 to 18 December 2021. The survey received 65 responses of which 50 were complete and usable for the study (i.e., rate of success of 67%). The final panel is consistent for dimension, heterogeneity, and experience of respondents. Indeed, 70% of respondents have more than 10 years of experience in the maritime logistics industry and 36% more than 20 years. The responses came from 23 different countries worldwide (Figure 2), resulting in a more comprehensive evaluation of salient beneficiary PSGs.

FIGURE 2

Moreover, 38% of respondents work in universities or research centres and 30% in PMBs (Figure 3). The rest of the panel has a role in private companies (e.g., shipping companies, transport and logistics companies, terminal operators, financial operators, etc.) or public entities (e.g., municipalities, regions, transport-related ministries, national or international regulatory agencies, etc.) dealing with the maritime logistics industry.

FIGURE 3

The international experts were asked to fill out the questionnaire by scoring on a 7-points Likert scale the expected benefits for each PSGs arising from each GS included in our taxonomy. A score of 1 corresponds to "no benefits" whereas the score 7 to "maximum benefits". Table 5 reports the “salient beneficiary stakeholders’ matrix” filled out by the international experts according to their perspective and experience. It reports the identified 8 typologies of GSs on the rows and the 10 PSGs on the columns. The average scores of each combination of the matrix were used to estimate the stakeholder prioritisation for GS by PMBs.

Finally, the matrix was tested on the Italian case studies to carry out the last step of the indirect approach. In this perspective, the average scores were used as coefficients (c_i where $i = 1,2,....80$) and multiplied for the number of GSs of each typology performed by the Italian PMBs of the sample (n_j where $j = 1,2,....8$). The sum of the results of each column ($\sum c_i \times n_j$) constitutes the total score achieved by each PSG. The relative scores (i.e., $\sum c_i \times n_j / \sum\sum c_i \times n_j$) represent the estimation of stakeholder prioritisation for GSs performed by the Italian PMBs of the sample.

The theoretical and empirical findings are reported and discussed in Section 5. The scores of the salient beneficiary stakeholders’ matrix were normalised for a deeper understanding of the findings.

TABLE 5

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5. Findings: The Italian port cases

5.1. The main typologies of green strategies and related CSR objectives

Figure 4 reports the main typologies of GSs performed by selected Italian PMBs and related CSR objectives. The majority of GSs addresses actions and interventions for improving port energy efficiency (i.e., 26% of the sample), followed by green policies and measures (19%), and research and development investment (15%). Quite surprisingly, only 2 interventions of the sample concern land use conversion.

When it comes to the CSR related objectives, economic and market objectives are the most pursued by sample GSs (38% and 24% of the sample, respectively). Governance objectives rank third (17%), followed by social (14%) and regulatory objectives (7%).

The findings per single PMB are reported in Figure 5. The Western Ligurian Sea Port Authority shows the widest and most diversified array of GSs. The principal typology of interventions addresses energy efficiency (i.e., 7 out of 28 of the sample GSs), followed by facilities and infrastructure for electric energy supply (5). These categories include the construction of a high-efficiency cogeneration plant in the port of Genoa as well as the realisation of a smart grid in the port of Savona (See Appendix B). Over the last years, the Western

Ligurian Sea Port Authority has been the only PMB of the sample that has performed GSs for land use conversion (2). The two interventions called “Dune di Prà” aim to develop a "green zone" between the operational area of the port of Genoa Prà and the surrounding urban areas both to reduce the acoustic impact of port works and to offer citizens a new space to live in the open air by the sea. As regards the CSR objectives, the PMB reflect the figures of the overall sample. Indeed, economic and market are the principal objectives pursued by the Western Ligurian Sea Port Authority (12 and 6 GSs, respectively).

FIGURE 4

The Eastern Ligurian Sea Port Authority shows a significant focus on renewable energy production, as well as policies and measures (7 GSs for each typology). Indeed, it reports the highest number of interventions for the installation of photovoltaic production systems (5). Moreover, the Eastern Ligurian Sea Port Authority has established different incentives for supporting the implementation of renewable energy sources by shipowners and terminal operators (Appendix C). The main goal pursued is economic objective (50%), whereas social objectives are completely neglected.

FIGURE 5

A specialisation in the GSs addressing digitalisation and ICT platforms emerges in the North Tyrrhenian Sea Port Authority (7 out of 16 GSs). Moni.C.A. and iNGENIOUS are some examples of the projects carried out by the PMB for the development of digital innovation systems (Appendix D). Research and development constitute another important typology of GSs as demonstrated by the 7 projects performed by the PMB (e.g., PROMO-GNL and Portfoward). The other typologies of GSs are almost neglected even though bunkering and storage, and policies and measures report 1 GS each. Contrary to other sample PMBs, the market objectives are most pursued (50%), followed by social (25%), and governance objectives (19%).

Finally, the Sardinian Sea Port Authority shows a strong commitment to GSs for energy efficiency (67%), including the projects GESTA and LUCE in the port of Cagliari (Appendix E). Moreover, the PMB has actively participated in the project GNL Facile for encouraging the deployment of LNG as marine alternative propulsion. As concerns CSR related objectives, economic objective ranks first (47%), followed by governance (33%) and social (13%). No regulatory objectives are pursued by the PMB.

5.2. The salient beneficiary stakeholders of green strategies

Table 6 reports the findings of the questionnaire sent to the panel of international experts. The average scores stress the salient beneficiary PSGs of each typology of GSs.

The principal beneficiaries of the GSs for digitalisation and ICT platforms are terminal operators (score 5.8 on average), followed by carriers (5.5) and port users (5.5). Innovative digital tools are called to reduce the impact of maritime logistics activities and accelerate freight travel information, cargo and capacity management, and security-related implementations.

The second typology of GSs (i.e., energy efficiency) brings higher benefits to terminal operators (5.6), local community and societal groups of interests (5.6), and shareholders/owners (5.4). When it comes to terminal

operators and shareholders/owners, they take advantage of the reduction in energy savings and related costs thanks to more efficient energy systems. Local community and societal groups of interests directly benefit from the decrease of pollutants arising from port activities' energy consumption.

GSs addressing renewable energy production show similar findings compared to the interventions for energy efficiency because they both deal with energy management and production. In this case, local community and societal groups of interests are the most beneficiary PSGs (5.5) since the use of renewable sources may generate higher benefits in terms of reduction of environmental impacts compared to energy efficiency.

TABLE 6

Unsurprisingly, carriers are by far the main beneficiaries of the GSs for the realisation of bunkering and storage facilities for alternative fuels (score 5.6 on average) whereas terminal operators rank second (5.3). Indeed, these PSGs represent the demand and supply of bunkering and storage services. In this perspective, the construction of new infrastructure and facilities for the refuelling of alternative fuels should generate significant market opportunities for these PSGs in addition to the inherent environmental benefits. For the same reason, carriers and terminal operators are also the principal targets of GS addressing the construction of facilities and infrastructure for electric energy supply.

The GSs for land use conversion provide the highest benefits to the local community and societal groups of interests (6.1). Moreover, these GSs are the only ones that provide high benefits to passengers (5.0). Contrary, terminal operators and carriers do not benefit from land use conversion because these interventions mainly rely on social purposes.

Finally, the main beneficiary PSGs of GSs for research and development are considered local community and societal groups of interests (5.4) and shareholders or owners (5.4). In most cases, these GSs are (co-)financed by European or national funds that require special attention to social issues along with environmental ones. This results in major benefits for local communities living in maritime cities or nearby.

5.3. Stakeholder prioritisation for green strategies

The normalised relative scores of the salient beneficiary stakeholders' matrix are reported for each PMB in Table 7. The rows define the PSGs hierarchy of the Italian PMBs. Each cell value stresses the prioritisation for each PSG as a percentage.

TABLE 7

Overall, terminal operators appear as the principal target of GSs (15.3% on average), followed by the local community and societal groups of interests (14.6%), and shareholders/owners rank third (14.0%). Surprisingly, a lack of attention emerges for passengers, and employees and labour unions respectively, the last and the penultimate of the prioritisation ranking.

Although no significant differences are noticed among the scores achieved by each PSG, some peculiarities emerge for each PMB of the sample. The Western Ligurian Sea and Sardinian Sea Port Authorities prioritise local community and societal groups of interest (respectively, 15.8% and 16%), whereas terminal operators

are the first target for Eastern Ligurian Sea and North Tyrrhenian Sea Port Authorities (15.4% and 15.5%). The North Tyrrhenian Sea Port Authorities show a considerable interest for port users and carriers (13.4% and 12.3%) compared to the other PMBs of the sample (respectively, 11.7% and 10.6% on average). This is mainly due to the high number of GSs addressing the realisation of digital platforms that mainly pursue market objectives.

6. Conclusion

The paper addresses the emerging topic of GSs in the port domain, according to a strategic management perspective. It provides a conceptual framework based on the CSR and stakeholder relationship management principles to disentangle the main typologies of GSs performed by PMBs and estimate the stakeholder prioritisation through an indirect methodological approach. The paper empirically tests the conceptual framework on four Italian PMBs to answer the two research questions.

According to RQ1 (i.e., the identification of the principal typologies of GS performed by PMB and the related CSR objectives), there are three main typologies of GSs, namely energy efficiency (i.e., 26% of the sample), green policies and measures (19%), and research and development investment (15%). The findings also confirm the urgency of Italian ports to meet the requirements belonging to the European Green Deal by introducing emerging digital technologies to favour the green transition: 11% of GSs deals with digitalisation and ICT platforms. The number of GSs for the realisation of facilities and infrastructure for electric energy supply (9%) and bunkering and storage facilities for alternative fuels (5%) stress the commitment of Italian PMBs to meet the recent EU legislative proposals "Fit for 55" for reducing by at least 55% GHG emissions by 2030. Moreover, these EU proposals were established to realise strategic recharging points for vehicles throughout the TEN-T core network as well as install refuelling stations for alternative fuels. Since some of the Italian ports of selected PMBs are core ports of the network (i.e., Genoa, La Spezia, Livorno, and Cagliari) they have been founded to increasingly invest in these typologies of GSs.

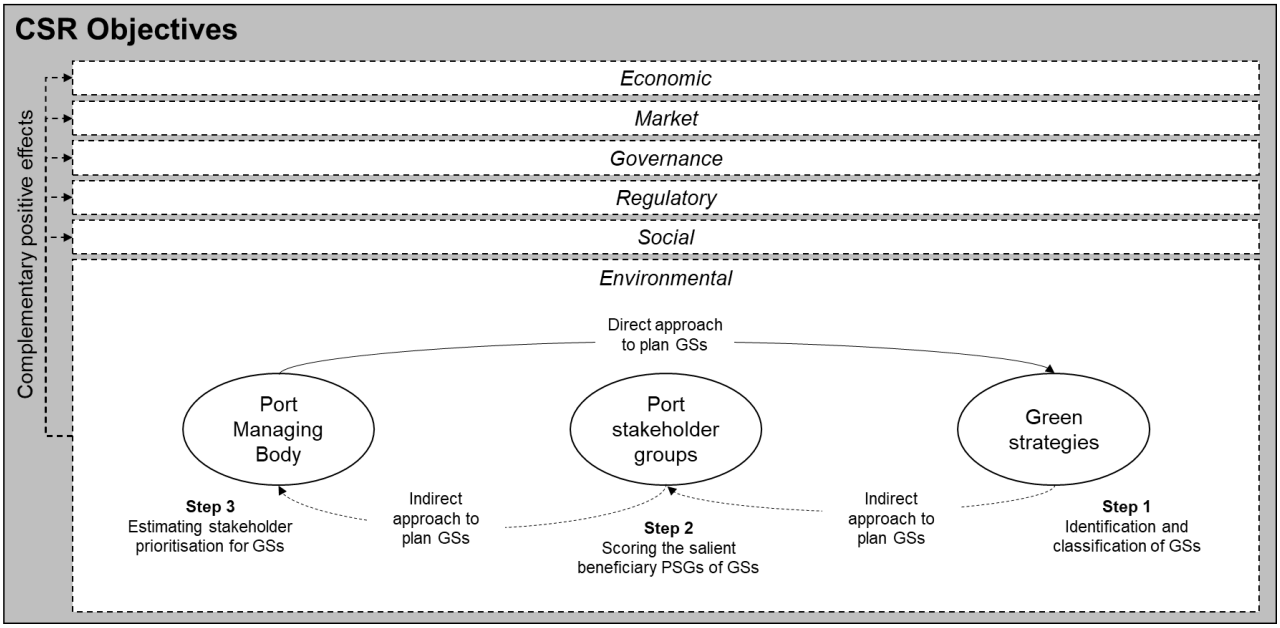
When it comes to the CSR related objectives, economic and market objectives are by far the most pursued by the Italian PMBs of the sample (38% and 24%, respectively). Economic objectives regard port value creation, increase of competitiveness and operational efficiency, whereas market objectives deal with satisfaction of maritime cluster firms' expectations, and effective response to competitors and market pressure. In this perspective, the findings demonstrate the importance of GSs for both reducing the environmental impact of port activities and increasing the competitiveness of the Italian port system. Moreover, they highlight the potential of GSs for facilitating new collaborations and strengthening the relationships with all PSGs according to the CSR principles.

The empirical indirect approach used to estimate stakeholder prioritisation (i.e., RQ2) shows the three salient PSGs of the Italian PMBs are terminal operators, local community and societal groups of interests, and shareholders/owners. The findings demonstrate GSs have significant ramifications to social matters as evidenced by the great attention for local communities (14.6% on average), stressing the relevance of GSs to achieve social approval and licence to operate. Quite surprisingly, employees and labour unions hold a low position in the PSG hierarchy. Although Italian PMBs are highly sensitive to social issues concerning port labour, as reported in the respective Strategic Planning Document of Port System (DPSS) and related specific initiatives, GSs do not seem to bring significant benefits for port workers. Indeed, safety at the workplace and labour rights are hot topics in the port domain but they seem to be marginally linked to GSs.

The paper contributes to the academic debate on sustainability in the port domain providing an overarching taxonomy of GSs of PMBs. The manuscript also stresses the multiple goals of GSs, consistent with the CSR perspective, and it traces the trends of green initiatives in the Italian ports to meet the diverse PSGs' expectations. Port managers can benefit from the proposed empirical indirect approach for stakeholder prioritisation and relate insights to improve the decision-making process concerning GSs. In this perspective, they can optimise the portfolio of GSs to maximise the benefits for specific target PSGs.

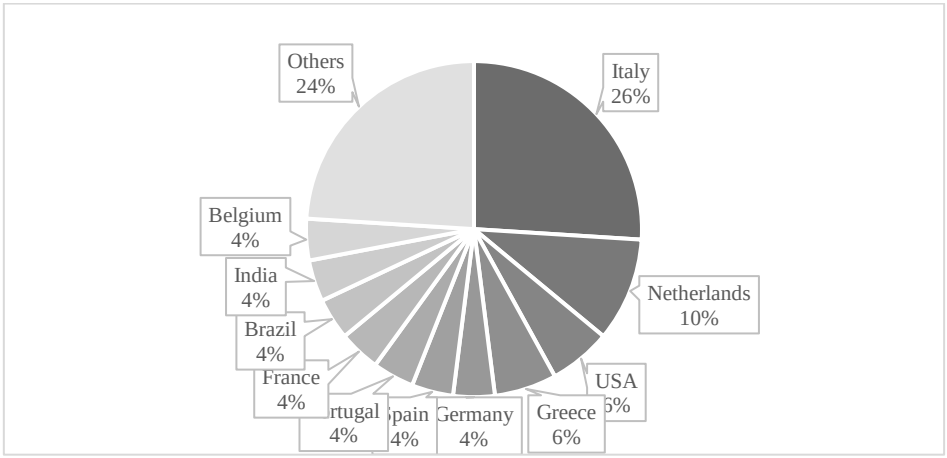
Nonetheless, the paper suffers some limitations. First, the sample of PMBs should be extended to investigate a wider number of GSs and compare the results emerging from different national port systems. Second, the paper evaluates the benefits for PSGs according to the perspective of the international experts included in the panel to which the survey has been administered, thus bringing some bias to the empirical analysis. To improve the consistency of the coefficients related to the GSs-PSGs matrix, future studies should consider PSGs' perspective and evaluate their perception of benefits arising from each typology of GSs.

Figure 1. Green strategies, CSR objective and beneficiary salient stakeholders: a conceptual framework.



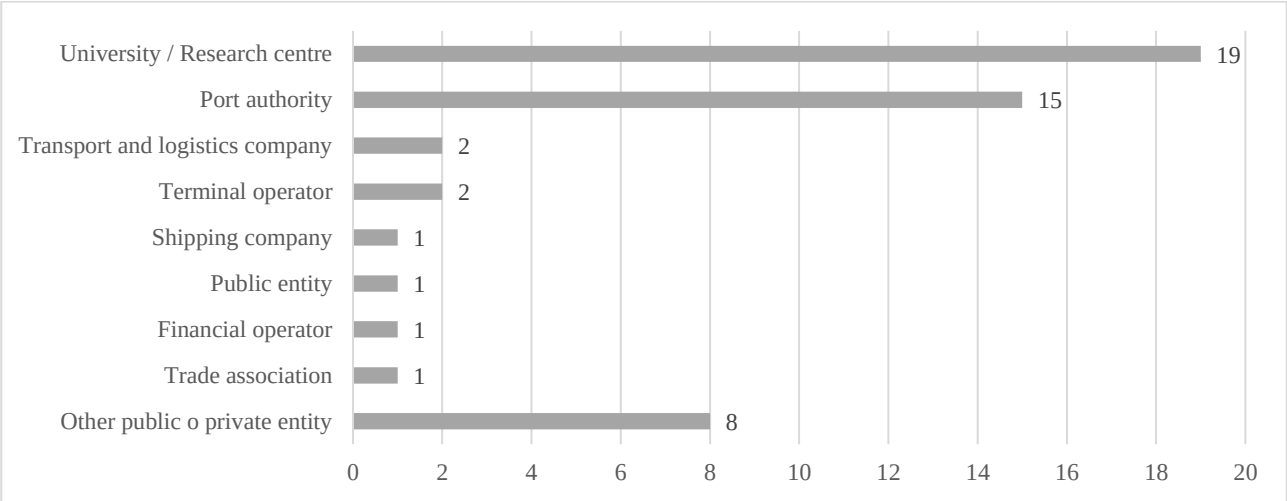
Source: authors' elaboration

Figure 2. Descriptive statistics of the survey respondents: country of employment.



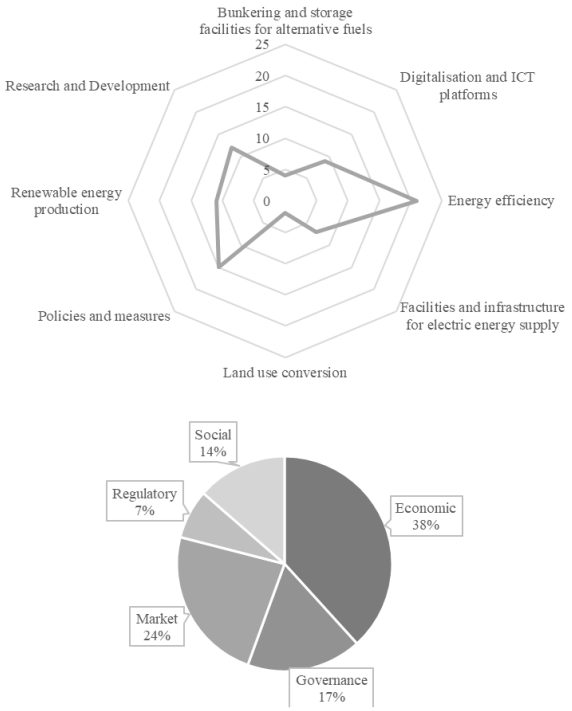
Source: authors' elaboration

Figure 3. Descriptive statistics of the survey respondents: type of company or public entity



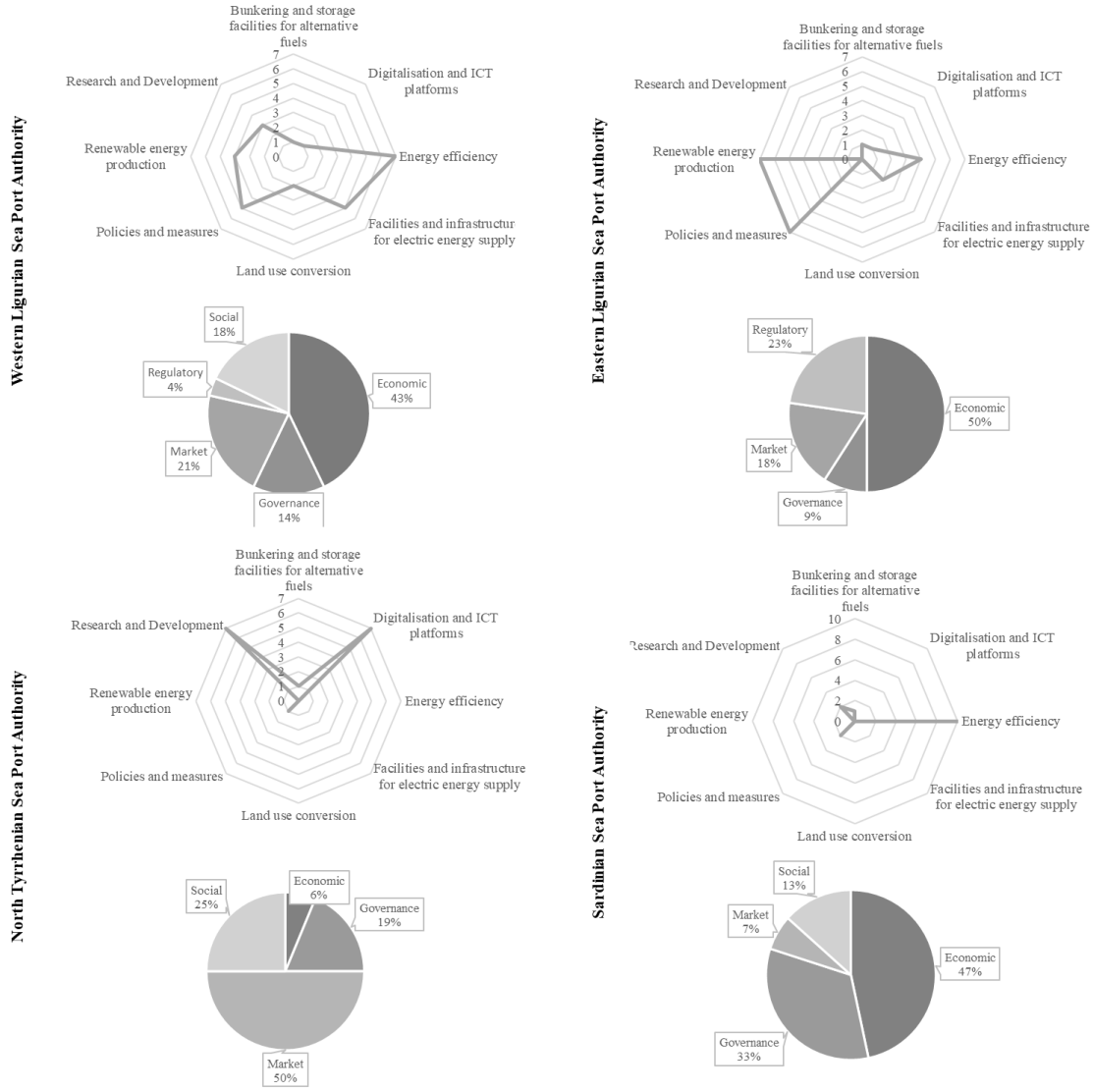
Source: authors' elaboration

Figure 4. Green strategies typologies and related CSR objectives: The Italian port case.



Source: authors' elaboration

Figure 5. The main findings of selected Italian PMBs.



Source: authors' elaboration

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Tables

Table 1. CSR-related objectives of green strategies performed by port managing bodies.

CSR-related objective	*Description*	*Literature*
Environmental	Reduction of environmental impact, climate change adaptation and mitigation, cut harmful emissions and other externalities on land and water.	Bailey and Solomon, 2004; Dinwoodie et al., 2012; Acciaro et al., 2014a; Davarzani et al., 2016; Martínez-Moya et al., 2019; Sdoukopoulos et al., 2019; Alamoush et al., 2021.
Economic	Business and economic growth, port value creation, increase of competitiveness, increasing operational efficiency, and reduction of costs.	Acciaro, 2015; Puente-Rodríguez et al. 2016; Kang and Kim 2017; Woo et al., 2018; Castellano et al., 2020.
Market	Satisfaction of maritime cluster firms' expectations, effective response to competitors and market pressure, improvement of quality and variety of services in line with customer demands.	Acciaro et al. 2014b; Acciaro 2015; Poulsen et al., 2018; Ashrafi et al., 2020; Castellano et al., 2020.
Governance	Leadership ethics, collaboration with port stakeholders, more sustainable governance structure and practices.	Lam and Notteboom 2014; Acciaro 2015; Puente-Rodríguez et al. 2016; Poulsen et al., 2018; Yoshitani 2018; Ashrafi et al., 2019; Schrobback and Meath, 2020.
Regulatory	Compliance with national and international regulation, the definition of stricter policies and measures at port level.	Acciaro et al., 2014a; Hiranandani 2014; Lam and Notteboom 2014; Le et al. 2014; Puente-Rodríguez et al. 2016; Kang and Kim 2017; Poulsen et al., 2018; Woo et al., 2018.
Social	Legitimacy from local communities, social licence to operate, improvement of public image, protection of human health, the definition of social initiatives.	Hiranandani 2014; Acciaro 2015; López-Navarro et al., 2015; Notteboom et al. 2015; Puente-Rodríguez et al. 2016; Kang and Kim 2017; Poulsen et al.,2018. Ashrafi et al., 2020; Stein and Acciaro, 2020.

Source: authors' elaboration.

Table 2. Sample green strategies.

Port Authority	No. of green strategies	% of the sample
Western Ligurian Sea	*28*	*35%*
Eastern Ligurian Sea	*22*	*27%*
North Tyrrhenian Sea	*16*	*20%*
Sardinian Sea	*15*	*19%*
Overall	**81**	**100%**

Source: authors' elaboration

Table 3. Green strategies typology.

Green strategies typologies	Description
Digitalisation and ICT platforms	Development of digital solutions (e.g., IoT, blockchain, etc.) to reduce the environmental impacts of maritime logistics activities in the port domain by improving their operational efficiency. These strategies also include ICT platforms, smart sensors, and other technologies for monitoring emissions and, in general, environmental externalities in the port domain.
Energy efficiency	Strategies to improve the energy efficiency of maritime logistics activities in the port domain. They include the replacement of lighting systems and other technical and technological solutions to reduce energy consumption and related GHGs and harmful emissions.
Renewable energy production	Development and installation of renewable energy production systems in the port domain. These strategies include the installation of photovoltaic panels as well as the use of wind and wave power to produce energy.
Policies and measures	Policies and incentives to stimulate maritime logistics actors to adopt greener practices and behaviours. They include measures for the acquisition of green energy as well as the establishment of special technical committees for monitoring and promoting the environmental commitment of the maritime cluster. They can also refer to agreements for creating networks aiming at supporting the port's green transition.
Bunkering and storage facilities for alternative fuels	Construction of bunkering and storage facilities for alternative fuels in the port domain, including liquefied natural gas, hydrogen, ammonia, biofuels, etc.
Facilities and infrastructure for electric energy supply	Construction of facilities and infrastructure for electric energy supply in the port domain. These strategies include the electrification of docks (i.e., cold ironing) and facilities for charging electric vehicles.
Land-use conversion	Strategies for converting the current intended use of specific port areas in favour of local communities. They include the construction of new neighbourhoods, parks, museums, and edutainment centres focused on the maritime logistics industry, as well as touristic attractions.
Research and Development	Projects and studies carried out by the PA/PMB (alone or with scientific/industrial partners) to achieve a more sustainable port.

Source: authors' elaboration.

Table 4. Port stakeholder groups (PSGs).

Group	Description
Shareholders/owners	Public entities or private organisations/firms holding an equity share in the Port Authority (PA) or Port Managing Body (PMB) or are entitled to appoint PA/PMB board of directors or executive directors.
Financial community	Financial and credit institutions that provide financial resources to support PA/PMB investment decisions and port development.
Employees and labour unions	Labour unions and people working at both executive and operational levels in the PA/PMB, public institutions (customs, coast guard, etc.) concessionaires, as well as labour pools.
Terminal operators	Firms that own or otherwise operate a terminal through a concession.
Other concessionaires	Firms holding at least a concession in the port area related to warehouses, industrial areas, logistics platforms, malls, or commercial areas.
Carriers	Shipping lines (container, ro-ro, cruise companies, etc.) and tramp operators (liquid bulk, dry bulk, etc.).
Port users	Freight forwarders, ship agents, brokers, road hauliers, railway companies, logistics providers, etc.
Passengers	A traveller on a ferry or a cruise ship who passes through the port for embarking/disembarking.
Local community and societal groups of interests	People and organisations located in the proximity of the port areas and directly or indirectly affected by the port operation and business.
Regulatory agencies	Policymakers and public institutions setting the institutional framework and governance mechanisms

Source: Authors' elaboration.

Table 5. The salient beneficiary stakeholders' matrix.

Green strategy	Shareholders/ owners	Financial community	Employees and labour unions	Terminal operators	Other concessionaires	Carriers	Port users	Passengers	Local community and societal groups of interests	Regulatory agencies	Total score
Digitalisation and ICT platforms	$c_1 \times n_1$	$c_2 \times n_1$	…	…	…	…	…	…	…	$c_{10} \times n_1$	$\sum c_i \times n_1$
Energy efficiency	…	…	…	…	…	…	…	…	…	…	…
Renewable energy production	…	…	…	…	…	…	…	…	…	…	…
Policies and measures	$c_i \times n_4$	$c_i \times n_4$	…	…	…	…	…	…	…	$c_i \times n_4$	$\sum c_i \times n_4$
Bunkering and storage facilities for alternative fuels	…	…	…	…	…	…	…	…	…	…	…
Facilities and infrastructure for electric energy supply	…	…	…	…	…	…	…	…	…	…	…
Land-use conversion	…	…	…	…	…	…	…	…	…	…	…
Research and Development	$C_{71} \times n_8$	$c_{72} \times n_8$	…	…	…	…	…	…	…	$C_{80} \times n_8$	$\sum c_i \times n_8$
Total score	$\sum c_i \times n_j$	…	…	…	…	…	…	…	…	$\sum c_i \times n_j$	$\sum\sum c_i \times n_j$
Relative score	$\sum c_i \times n_j / \sum\sum c_i \times n_j$	…	…	…	…	…	…	…	…	$\sum c_i \times n_j / \sum\sum c_i \times n_j$	**1**

Source: authors' elaboratio

Table 6. The salient beneficiary stakeholders' matrix: coefficients.

Green strategy	Shareholders/ owners	Financial community	Employees and labour unions	Terminal operators	Other concessionaires	Carriers	Port users	Passengers	Local community and societal groups of interests	Regulatory agencies
Digitalisation and ICT platforms	5.1	4.7	4.4	5.8	4.9	5.5	5.5	4.9	4.9	5.3
Energy efficiency	5.4	4.9	4.4	5.6	5.2	4.9	5.0	4.3	5.6	4.9
Renewable energy production	5.4	5.1	4.1	5.3	5.1	4.6	4.7	4.1	5.5	5.0
Policies and measures	5.4	5.0	4.4	5.4	5.1	5.1	5.2	4.2	5.3	5.3
Bunkering and storage facilities for alternative fuels	5.2	4.7	4.2	5.3	4.9	5.6	5.0	3.7	4.7	4.8
Facilities and infrastructure for electric energy supply	5.2	4.8	4.3	5.5	5.1	5.6	5.4	4.4	5.5	5.0
Land-use conversion	4.8	4.4	4.4	3.9	4.1	3.5	4.1	5.0	6.1	4.7
Research and Development	5.4	5.1	4.7	5.2	5.1	5.0	5.2	4.3	5.4	5.3

Source: authors' elaboration

Table 7. Stakeholder prioritisation for green strategies by Italian port managing bodies.

PMB	Shareholders/owners	Financial community	Employees and labour unions	Terminal operators	Other concessionaires	Carriers	Port users	Passengers	Local community and societal groups of interests	Regulatory agencies
Western Ligurian Sea	14.1%	8.7%	2.0%	14.7%	10.9%	10.4%	11.4%	1.3%	15.8%	10.8%
Eastern Ligurian Sea	14.5%	9.3%	1.1%	15.4%	11.3%	10.2%	11.0%	0.6%	15.2%	11.4%
North Tyrrhenian Sea	12.8%	7.5%	2.6%	15.5%	9.4%	12.3%	13.4%	2.6%	11.6%	12.4%
Sardinian Sea	14.7%	8.5%	2.7%	15.8%	11.7%	9.6%	10.9%	0.0%	16.0%	10.1%
Average	14.0%	8.5%	2.1%	15.3%	10.8%	10.6%	11.7%	1.1%	14.6%	11.2%

Source: authors' elaboration

Figure legends

Figure 1 *reports the conceptual framework provided by the authors to disentangle green strategies in the port domain.*

Figure 2 *reports the country of employment of the 50 different respondents of the questionnaire.*

Figure 3 *reports the type of company or public entity the 50 different respondents of the questionnaire work for.*

Figure 4 *reports the main typologies of GSs performed by selected Italian PMBs and related CSR objectives.*

Figure 5 *reports the main typologies of GSs and related CSR objectives performed by each PMB of the sample.*

Appendices

Appendix A. Sample PMBs: key facts and statistics.

CASE STUDY	DESCRIPTION	GREEN COMMITMENT
Western Ligurian Sea Ports	The PMB manages in total 4 ports, i.e., the ports of Genoa, Genoa Prà, Savona, and Vado Ligure. In 2020, around 7,000 ships arrived in the so called "Ports of Genoa", that represent one of the most important port systems in the Mediterranean. It handled around58.5 million tonnes of cargo (-14.2% compared to 2019); 2.5 million TEU (-6.5% compared to 2019). Overall, more than 1.5 million passengers passed through the Ports of Genoa (- 90% for cruise and 50% for ferry traffic compared to 2019) (Assoporti, 2020). The Port of Genoa is the largest and most important Italian port. Top private terminal operators worldwide conduct the business in the port of Genoa and provide a wide array of services to accommodate all classes of ships. The port of Savona is the fourth largest cruise port in Italy in terms of the number of passengers and is among the very first in the Mediterranean.	Over the last years, the Western Ligurian Sea Port Authority has introduced new environmental policies for harmonising the relationship between the ports and the cities and foster the sustainable development of all port activities. The PMB has adopted new practices for water and air monitoring as well as waste management. In the ambitious DEASP, the Western Ligurian Sea Port Authority aims to improve the use of renewable sources and energy saving methods. To achieve these goals, it has been collaborating closely with public entities and private operators of the maritime cluster. Moreover, it has carried out public consultations with local communities to properly understand their requirements.
Eastern Ligurian Sea Ports	The PMB manages in total 2 ports (i.e., the port of La Spezia and Marina di Carrara). In 2020, the port system handled around: 16 million tonnes of cargo (-15,1% compared to 2019); 1,2 million TEU (-15.5% compared to 2019) (Assoporti, 2020). The Port of La Spezia is one of Italy's major commercial ports of call.	One of the main strategic objectives of the Eastern Ligurian Sea Port Authority is to protect the environment by minimising the impacts related port and maritime activities. The PMB is committed to develop new practices and digital systems for monitoring the air and water quality in the Gulf of La Spezia. Moreover, it aims to improve energy production from renewable sources and promote the electric mobility within the port. Finally, the Eastern Ligurian Sea Port Authority is realising power supply system infrastructure (i.e., cold ironing) in the cruise terminal of Molo Garibaldi and new railway tracks for improving rail transport.
North Tyrrhenian Sea Ports	The PMB manages in total 6 ports (i.e., the ports of Livorno, Capraia, Piombino, Rio Marina, Portoferraio, and Cavo). In 2020, it handled around: 37.6 million tonnes of cargo (-16% compared to 2019); 716.233 TEU (-9.32% compared to 2019); 6 million passengers (-39,8% compared to 2019.) (Assoporti, 2020). The port of Livorno is in the northern basin of the Tyrrhenian Sea and represents a crucial junction within the TEN-T network. It can rely on high-tech facilities and superstructures and on its strongly multifunctional nature.	The North Tyrrhenian Sea Port Authority is actively committed to promoting the sustainable development and decarbonisation of the port system and the sustainable use of natural resources. The fight against the climate change is recognised as one of the main objectives of the port. For this reason, the North Tyrrhenian Sea Port Authority is participating in many research projects for promoting the use of alternative energy sources and digital technologies aimed at reducing the environmental impacts of port and maritime activities.
Sardinian Sea Ports	The PMB manages in total 7 ports (i.e., the ports of Cagliari, Olbia, Golfo Aranci, Porto Torres, Oristano, Portovesme, and Santa Teresa Gallura). In 2020, it handled around: 38,4 million tonnes of cargo (-16,9% compared to 2019); 68.406 TEU (-54% compared to 2019); 3.5 million of passengers (-46,9% compared to 2019) (Assoporti, 2020). The port of Cagliari is located on the southern side of Sardinia a few miles away from the ideal line connecting Gibraltar and Suez. Therefore, it represents one of the main strategic hubs in the western Mediterranean. The port of Olbia is one of the most important passenger ports of call in the Mediterranean, given its location which makes it a gateway to the vast tourist areas of the Costa Smeralda.	The DEASP of the Sardinian Sea Port Authority identifies the following primary objectives related to energy and environmental management: adoption of energy efficiency measures and solutions; use of innovative technologies to lower the environmental impact of maritime logistics activities; improvement the energy production from renewable sources; fostering the cooperation with public entities and private operators of the maritime cluster.

Source: authors' elaboration on data and information published on the corporate websites of the sample Italian PMBs and related strategic planning documents and reports on environmental and energy management.

Appendix B. Western Ligurian Sea Port Authority.

Project title	Timeframe period	Description	Budget (M €)	Environmental benefits	GS Typology	GS Objective
Cold Ironing-Genoa Cruises and Ferries terminal	2021-ongoing	Realization of cold ironing infrastructure in the Genoa Cruises and Ferries terminal.	29.4	Annual reduction of CO2, NOx and PM2.5 emissions parameterised based on the results of the electrification of the docks of the Genova Prà container terminal.	Facilities and infrastructure for electric energy supply	Market
Cold Ironing-Terminal Container Genova Pra'	2021-ongoing	Realization of cold ironing infrastructure in the Genoa Prà terminal.	9	Annual reduction of CO2 emissions equal to 2,800 t/year, NOx equal to 89.3 t/year, PM2.5 equal to 2.1 t/year. This reduction is due to the reduction in MGO consumption of 1,520 t/year.	Facilities and infrastructure for electric energy supply	Market
Construction of a high-efficiency cogeneration plant in the Sampierdarena Area-Port of Genoa	2020-2022	Reduction of energy consumption through the development of a new cogeneration system in the current thermal power plant by gradually replacing boilers with congenators.	6.8	Annual reduction of CO2 emissions equal to 2,820 t/year, NOx equal to 6.45 t/year, PM2.5 equal to 0.15 t/year.	Energy efficiency	Economic
Construction of a high-efficiency trigeneration plant in the Prà Area-Port of Genoa	2020-2022	Reduction of energy consumption through the construction of a new trigeneration plant in the Port of Genoa	1	Annual reduction of CO2 emissions equal to 603.1 t/year, NOx equal to 1.31 t/year, PM2.5 equal to 0.03 t/year.	Energy efficiency	Economic
Dune di Prà-1	2019-2020	Creation of a "green zone" between the operational areas of the port and the urban context both to reduce the acoustic impact of port works and to offer citizens a new space to live in the open air by the sea.	1.7	Landscape and noise mitigation.	Land use conversion	Social
Dune di Prà-2	2021-ongoing	Creation of a "green zone" between the operational areas of the port and the urban context both to reduce the acoustic impact of port works and to offer citizens a new space to live in the open air by the sea.	15.5	Landscape and noise mitigation.	Land use conversion	Social
Energy efficiency interventions on "Officina Bruzzo" plants-Port of Genoa	Concluded in 2020	The intervention of energy efficiency for the decommissioning of the current central heating and related auxiliary systems and the installation of a hydronic heat pump sized to air-condition only the volumes used.	0.1	Annual reduction of CO2 emissions equal to 83 t/year thanks to the reduction in the use of diesel.	Energy efficiency	Economic
Establishment of the DEASP Committee	2020-ongoing	Establishment of a special Technical Committee called the "DEASP Committee", which will be entrusted to implement the program of interventions provided by the DEASP.	nd	Supporting decision making process and adoption of a new solution for energy efficiency and reduction of environmental impacts.	Policies and measures	Governance

GNL FACILE	2018-2021	Encourage a progressive reduction in the use of the most polluting fuels and dependence on oil and promoting the deployment of LNG for maritime propulsion.	2.3	The adoption of LNG for shipping will reduce about 20% of CO2, over 99% of SOx and PM, and 80% of NOx emitted by boats.	Bunkering and storage facilities for alternative fuels	Market
GRAMAS	2018-2021	Bathymetry survey campaigns in the harbour water mirror.	nd	Development of common systems to manage the phenomenon of silting up of ports and synergies on the issue of risks linked to climate change.	Research and Development	Governance
IMPATTI-NO	2018-2021	Improvement of the managerial practices for port-waste through the development of a circular economy model.	2	Identification of the best waste and effluent treatment technologies in port areas. Supporting the development of the circular economy.	Research and Development	Social
Incentives for the purchase of green energy	2020-2022	Incentives for concessionaires to purchase electricity produced exclusively or largely from renewable sources.	nd	Annual reduction of CO2 emissions equal to 13,706 t/year, NOx equal to 10.3 t/year, PM2.5 equal to 0.2 t/year	Policies and measures	Governance
INES	2015-2021	Electrification of the docks of the port terminal of Genova Prà to achieve a significant reduction of polluting and acoustic emissions produced by ships at berth.	4.5	Annual reduction of CO2 emissions equal to 2,800 t/year, NOx equal to 89.3 t/year, PM2.5 equal to 2.1 t/year. This reduction is due to the reduction in MGO consumption of 1,520 t/year.	Facilities and infrastructure for electric energy supply	Market
Information campaign for port stakeholders on sustainability issues.	2020-ongoing	Increasing awareness of civil society on the efforts of AdSP on sustainability issues.	nd	Implementation of shared measures to reduce environmental impacts by also informing and involving local communities.	Policies and measures	Social
Installation of electric vehicle charging stations and purchase of vehicles-Port of Genoa	2020-2022	Installation of electric vehicle charging stations and interventions for the gradual replacement of service cars and commercial vehicles with new electric traction vehicles.	1.5	Annual reduction of CO2 emissions equal to 1,170 t/year, NOx equal to 4.9 t/year, PM2.5 equal to 0.03 t/year. This reduction is mainly attributable to the reduction in the use of diesel and petrol.	Facilities and infrastructure for electric energy supply	Market
Installation of electric vehicle charging stations and purchase of vehicles-Port of Savona/Vado Ligure	2020-2022	Installation of electric vehicle charging stations and interventions for the gradual replacement of service cars and commercial vehicles with new electric traction vehicles.	0.5	Annual reduction of CO2 emissions equal to 150 t/year, NOx equal to 0.6 t/year. This reduction is mainly attributable to the reduction in the use of diesel and petrol.	Facilities and infrastructure for electric energy supply	Market
Installation of LED lamps-Port of Genoa	Concluded in 2020	Replacement of sodium vapour lamps with LED lamps in cargo and passenger terminals within the port of Genoa.	0.6	Reduction of CO2 emissions by 920 t/year.	Energy efficiency	Economic
Installation of LED technology lamps in the public area-Port of Genoa	Concluded in 2020	Replacement of sodium vapour lamps with LED lamps in the outdoor areas of the port of Genoa.	0.3	Reduction of CO2 emissions by 85 t/year.	Energy efficiency	Economic

Installation of LED technology lamps in the public area-Port of Savona/Vado Ligure	Concluded in 2020	Replacement of sodium vapour lamps with LED lamps in the outdoor areas of the port of Savona/Vado Ligure	0.3	Reduction of CO2 emissions by 90 t/year.	Energy efficiency	Economic
Measure for energy efficiency and the exploitation of renewable sources	2020-2021	Incentives for concessionaires to carry out interventions aimed at improving their energy-environmental performance.	nd	Improvement of energy efficiency and use of renewable energy, thus reduction of GHG and pollutants.	Policies and measures	Regulatory
Measure for the acquisition of green energy	Concluded 2020	Purchase of green electricity from renewable sources for all users of the ports of AdSP of Mar Ligure Occidentale.	nd	Reduction of annual CO2 emissions of 970 t/year of NOx of 0.7 t/year.	Policies and measures	Governance
Monitoring and optimization system for energy-environmental performance	2020-2025	Implementation of an integrated ICT system for managing and optimising energy and environmental performance using an Energy Control Unit (ECU), interconnected, and integrated with a Web-GIS system.	nd	Reduction of energy requirement by 5-10% and thus CO2 emissions.	Digitalisation and ICT platforms	Economic
Photovoltaic system in the Stazioni Marittime Terminal-Port of Genoa	2020-2021	Installation of a photovoltaic system on the buildings of Stazione Marittima and replacement of natural gas boiler with air/water heat pump.	0.4	Annual reduction of CO2 emissions equal to 103 t/year (of which 23 t/year for reducing electricity consumption and 80 t/year for reducing LNG consumption), NOx equal to 0.1 t/year.	Renewable energy production	Economic
Photovoltaic systems on roofs of buildings located within the state boundaries-Port of Genoa	2020-2022	Realization of photovoltaic systems on the roof surfaces of buildings located within the state property boundaries in the port of Genoa. Total exploitable surface 123.880 sqm.	9.6	Reduction of annual CO2 emissions of 3,100 t/year, NOx of 2.4 t/year, PM2.5 of 0.1 t/year.	Renewable energy production	Economic
Photovoltaic systems on roofs of buildings located within the state boundaries-Port of Savona/Vado Ligure	2020-2022	Realization of photovoltaic systems on the roof surfaces of buildings located within the state-owned boundaries in the port of Savona-Vado Ligure. Total exploitable surface 54.720 sqm.	4.3	Reduction of annual CO2 emissions of 1,600 t/year of NOx of 1.2 t/year.	Renewable energy production	Economic
RUMBLE	2018-2021	Supporting sustainability practices in the port domain for reducing noise pollution.	1.9	Reduction of noise emissions and related externalities to local communities and the environment.	Research and Development	Social
Smart Grid in the Port of Savona	2020-2021	Realization of a "Smart Grid", i.e., an innovative electricity distribution network in the port of Savona-Vado Ligure.	nd	Optimisation of energy requirements and reduction of GHG emissions and pollutants.	Energy efficiency	Economic
Wave energy-Port of Genoa	2020-2022	Realization of a 1:1 scale prototype of the OWCM (Oscillating Water Column Motor) system.	15	Annual reduction of CO2 emissions equal to 1,600 t/year, NOx equal to 1.2 t/year.	Renewable energy production	Economic

Source: authors' elaboration

Appendix C. Eastern Ligurian Sea Port Authority.

Project title	Timeframe period	Description	Budget (M €)	Environmental benefits	GS Typology	GS Objective
Adaptation and energy efficiency of the lighting system in the port of Marina di Carrara	2018-2019	Increasing efficiency of the lighting system together with the lighthouse (today SAP type).	0.6	The expected reduction of CO2eq emissions by 256 t/year.	Energy efficiency	Economic
Blueconnect	2018-2020	The project wants to create a network of companies, institutions, operators of the sector and the territory, to the realization of a greener and smarter port of the future.	nd	Strengthening of relationships between public and private companies for the implementation of green strategies.	Policies and measures	Governance
Development of infrastructure LNG supply	nd	Development of a series of scenarios and projects to implement a strategic road map for the LNG supply chain in the Port of La Spezia.	nd	Supporting the deployment of LNG as a greener maritime fuel.	Bunkering and storage facilities for alternative fuels	Market
Electrification of the docks in the first port basin	2020-2025	Realization of cold ironing infrastructure in the port of La Spezia powered through an independent system of 10MW.	7.7	Expected reduction of CO2eq emissions: 3100 t/year (with electricity supply from 100% renewable sockets compared to the use of BTZ oil)	Facilities and infrastructure for electric energy supply	Market
Electrification of the docks in the Gulf Terminal	2021-2023	Realization of cold ironing infrastructure and network through one connection of 6 MW and one of 4 MW which will supply two ships simultaneously.	5.7	Expected reduction of CO2eq emissions: 1946 t/year (with electricity supply from 100% renewable sockets compared to the use of BTZ oil)	Facilities and infrastructure for electric energy supply	Market
Energy efficiency of buildings and outdoor areas within the port domain	nd	Planning and implementation of measures to reduce the energy consumption of different energy vectors, including concessionaires and port operators.	0.1	Improvement of energy efficiency equal to 130.000 kWh/year and thus reduction of CO2 and other harmful emissions.	Energy efficiency	Economic
Energy efficiency project-La Spezia Container Terminal	2019-2020	Replacement of the current SAP lights on RTG and STACKING cranes with a new LED lighting system that will achieve significant energy savings.	0.3	The expected reduction of CO2eq emissions by 301 t/year	Energy efficiency	Economic
Extension of the protocol for reducing the Impact of vessel emissions within port docks	nd	This protocol aims to improve the laws currently in force that require fuel changes within a maximum of two hours after the end of mooring operations with specific reference to switching to a fuel with a sulphur content of less than 0.1% by mass.	nd	Reduction of polluting gas emissions such as SOx, NOx, PM2.5, NMVOC.	Policies and measures	Regulatory

Green electricity supply measure	nd	Purchase of electricity on the market with a certificate of guarantee of the origin that would allow more accurate quantification of CO2eq emissions without using national conversion factors.	nd	Reduction of CO2 emissions by 30k tonnes	Policies and measures	Governance
Incentives for the implementation of energy efficiency measures for buildings and processes.	nd	Reduction of concession fees according to the reduction of CO2eq emissions through the implementation of energy efficiency measures on buildings or processes as well as the expense of the concessionaires.	nd	The expected reduction of CO2eq emissions by 1,000 t.	Policies and measures	Regulatory
Incentives for the implementation of Renewable Energy Sources (RES) plants	nd	Incentives related to the construction and adoption of RES by concessionaires.	nd	The expected reduction of CO2eq emissions by 3,000 t.	Policies and measures	Regulatory
Incentives to support shipowners and operators using electricity supplied by cold ironing	nd	Realization of some new mooring quays equipped with cold ironing in the port of La Spezia.	nd	The expected reduction of CO2eq emissions by 5,000 t.	Policies and measures	Regulatory
Incentives to support shipowners and operators using vessels with reduced environmental impact.	nd	The AdSP could incentivize the mooring of vessels characterized by a good ESI score (related to pollutant emissions) through a reduction in the value of mooring fees.	nd	Reduction of fuel consumption and GHG emissions by between 10% and 50% compared to the benchmark.	Policies and measures	Regulatory
Photovoltaic electricity production-Port of La Spezia	nd	Feasibility analysis to produce electricity from photovoltaics through an approach based on a GIS (Geographic Information System), which has allowed to realize a mapping of solar radiation and potential production of energy.	0.4	Supporting the deployment of renewable energy and cut of GHG emissions and pollutants.	Renewable energy production	Economic
Photovoltaic modules integrated into the soundproof barrier in the port city of La Spezia	2018-2019	Realization of a photovoltaic system to be installed on the road sound barriers near the road underpass with the adoption of photovoltaic modules of size 1000x1560mm with a peak power of 327 Wp.	0.1	The expected reduction of CO2eq emissions by 15 t/year.	Renewable energy production	Economic
Photovoltaic production system on the roof of the existing warehouse-Cantieri Apuania	2019-2020	Installation of a 100 kWp photovoltaic system on the roof of an existing shed: 9 strings are polycrystalline Sunerg XP 60/156-250, 250 Wp each.	0.1	The expected reduction of CO2eq emissions by 70 t/year.	Renewable energy production	Economic
Photovoltaic production system on the roof of warehouses-Ferretti SpA	Concluded in 2020	Installation of a 244.8 kWp photovoltaic system on the roof of two warehouses in the port of La Spezia.	0.3	The expected reduction of CO2eq emissions by 129 t/year.	Renewable energy production	Economic

Replacement of existing lighthouse with LED technology lighting towers-Port of La Spezia	2020-2022	Conversion of the approximately 1 kW high-pressure sodium (SAP) floodlights currently installed in 7 Lighthouse Towers to new high efficiency LED technology floodlights of approximately 300 W.	0.1	The expected reduction of CO2eq emissions by 201 t/year.	Energy efficiency	Economic
Strengthening of transport infrastructures system for CO2 reduction	nd	Upgrading and optimisation of the Varco Stagnoni to reduce bottlenecks and emissions from trucks.	6.4	Reduction of congestion and bottlenecks thus cut CO2 emissions and pollutants.	Digitalisation and ICT platforms	Market
Two photovoltaic production systems on the roofs of two warehouses in the project-The Italian Sea Group	2020-2021	Installation of two photovoltaic systems of 100 kWp each on the roof of two new warehouses.	0.3	Reduction of CO2eq emissions expected by 118 t/year.	Renewable energy production	Economic
Wave power generation	nd	A preliminary analysis for the installation of wave power systems in the Gulf of La Spezia and Marina di Carrara.	nd	Supporting the deployment of renewable energy and cut of GHG emissions and pollutants.	Renewable energy production	Economic
Wind power generation	nd	Installation of wind power generation systems in the Gulf of La Spezia and Marina di Carrara, analysing the data collected by the anemometer stations.	nd	Supporting the deployment of renewable energy and cut of GHG emissions and pollutants.	Renewable energy production	Economic

Source: authors' elaboration

Appendix D. North Tyrrhenian Sea Port Authority Port Authority.

Project title	Timeframe period	Description	Budget (M €)	Environmental benefits	GS Typology	GS Objective
Blueconnect	2018-2020	The project wants to create a network of companies, institutions, operators of the sector and the territory, to the realization of a greener and smarter port of the future.	nd	Strengthening of relationships between public and private companies for the implementation of green strategies.	Policies and measures	Governance
COREALIS	2018-2021	COREALIS proposes a strategic, innovative framework, supported by disruptive technologies to increase efficiency, and optimize land use, respecting circular economy principles.	nd	Reducing the port's total environmental footprint associated with intermodal connections and the surrounding urban environment for three major transport modes, road/truck, rail, and inland waterways.	Digitalisation and ICT platforms	Social
Easylog	2018-2021	Development of an innovative system for the optimisation of cargo flows. Establish a common intelligent cross-border traffic management system that can improve the logistics chain and maritime transport.	nd	Optimisation of cargo and information flows between AdSP and maritime logistics operators to reduce emissions arising from vehicles and other modes of transport.	Digitalisation and ICT platforms	Market
GNL FACILE	2018 -2021	Encourage a progressive reduction in the use of the most polluting fuels and dependence on oil and promoting the deployment of LNG for maritime propulsion.	2.3	The adoption of LNG for shipping will reduce about 20% of CO2, over 99% of SOx and PM, and 80% of NOx emitted by boats.	Bunkering and storage facilities for alternative fuels	Market
GRAMAS	2018-2021	Bathymetry survey campaigns in the harbour water mirror.	nd	Development of common systems to manage the phenomenon of silting up of ports and synergies on the issue of risks linked to climate change.	Research and Development	Governance
IMPATTI-NO	2018-2021	Improvement of the managerial practices for port-waste through the development of a circular economy model.	2	Identification of the best waste and effluent treatment technologies in port areas. Supporting the development of the circular economy.	Research and Development	Social
iNGENIOUS	2020-ongoing	The project aims to develop newly designed Internet of Things elements and ICT platforms for maritime logistics.	nd	Decrease the average time spent by vehicles in the port and thus reduce polluting emissions.	Digitalisation and ICT platforms	Market
Mon Acumen	2017-2021	The project aims to reduce the acoustic impact generated by ports.	nd	Reduction of noise emissions and related externalities to local communities and the environment.	Research and Development	Social
Moni.C.A.	2021-ongoing	Development of new application modules related to the Moni.C.A. system for the monitoring of environmental impacts and carbon footprint.	nd	Monitoring of carbon footprint and planning new solutions to reduce environmental impacts.	Digitalisation and ICT platforms	Market

PortForward	2018-2021	The project aims to provide innovative solutions to make the ports of the future smarter, greener, and more interconnected.	nd	Enhancement of sustainable development and management of the resources in the port domain.	Research and Development	Economic
PROMO GNL	2018-2021	The objective of the project is to achieve a coordinated framework of joint feasibility studies that will foster enlightened choices for promoting the optimal uses of LNG as a less polluting fuel in ports of commerce in the cooperation area.	0.7	Supporting the deployment of LNG as a greener maritime fuel.	Research and Development	Governance
RUMBLE	2018-2021	Supporting sustainability practices in the port domain for reducing noise pollution.	1.9	Reduction of noise emissions and related externalities to local communities and the environment.	Research and Development	Social
Smooth Ports	2019-ongoing	Reduce the environmental impact associated with cargo inspections at ports by developing best practices among the ports involved.	nd	Reduction of CO2 emissions.	Research and Development	Market
TPCS	2015-ongoing	Implementation of a Port Community platform for the paperless management of processes relating to the import and export of goods.	nd	Reduction of polluting gas emissions such as SOx, NOx, PM2.5, NMVOC.	Digitalisation and ICT platforms	Market
TPCS-implementation of VBS	Ongoing	Development of a module for the management of reservations for the release collection of goods in the port.	nd	Reduction of polluting gas emissions such as SOx, NOx, PM2.5, NMVOC.	Digitalisation and ICT platforms	Market
URSA MAJOR NEO	nd	Development of an ICT platform for the dynamic updating of the TPCS-VBS time slots.	nd	Reduction of polluting gas emissions such as SOx, NOx, PM2.5, NMVOC.	Digitalisation and ICT platforms	Market

Source: authors' elaboration

Appendix E. Sardinian Sea Port Authority.

Project title	Timeframe period	Description	Budget (M €)	Environmental benefits	GS Typology	GS Objective
Agreement for the provision of facility management services for buildings	2015-2021	The agreement provides multiple services, including maintenance services of plants, networks, minor maintenance of buildings, based on green practices.	1.4	Supporting the deployment of green practices in the port domain for the reduction of environmental impacts.	Policies and measures	Governance
Construction of the new headquarter of the Port Authority of Olbia and Golfo Aranci	Concluded in 2020	Construction of the new energy efficient headquarter of the Port Authority of Olbia and Golfo Aranci	nd	Improvement of energy efficiency of the new building and reduction of CO2 emissions.	Energy efficiency	Governance
Definition of a PPP for the assignment of electricity supply and management service for the public lighting systems and buildings	Ongoing	Establishment of a partnership aimed at the concession of multiple services, including the management of lighting and maintenance of the energy system.	4.7	Supporting the energy transition and the reduction of both GHG emissions and pollutants.	Policies and measures	Governance
Energy efficiency interventions in the offices of the Port Authority of Olbia and Golfo Aranci	nd	Installation of air conditioning systems with high energy efficiency performance in all offices as well as electrical and lighting systems.	nd	Improvement of energy efficiency and reduction of CO2 and harmful emission.	Energy efficiency	Economic
Energy requalification of the external lighting systems of the port of Portovesme	Concluded in 2018	Replacement of lighting fixtures and the modernization of some parts of the energy system to ensure compliance with the requirements of UNI EN 12464-2.	0.3	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Economic
Extraordinary maintenance and recovery of the lighting systems in the port of Porto Torres	Concluded in 2019	Maintenance of the lighting system of the selected areas in the port of Porto Torres to reduce the energy requirements and consumption.	0.4	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Economic
Extraordinary maintenance-Port of Olbia Isola Bianca	Concluded 2019	Construction of a new branch line to supply power to towers T18 and T19 as well as lighting systems with LED lights in the following areas.	0.4	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Economic
GESTA	nd	Upgrading and energy efficiency of the lighting systems as well as the management and supply of energy carriers.	5.7	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Economic
GNL FACILE	2018 -2021	Encourage a progressive reduction in the use of the most polluting fuels and dependence on oil and promoting the deployment of LNG for maritime propulsion.	2.3	The adoption of LNG for shipping will reduce about 20% of CO2, over 99% of SOx and PM, and 80% of NOx emitted by boats.	Bunkering and storage facilities for alternative fuels	Market

IMPATTI-NO	2018-2021	Improvement of the managerial practices for port-waste through the development of a circular economy model.	2	Identification of the best waste and effluent treatment technologies in port areas. Supporting the development of the circular economy.	Research and Development	Social
LUCE - Port of Cagliari	Concluded in 2018	The project aims to develop a Management Plan for the energy system in the port of Cagliari.	nd	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Governance
LUCE - Port of Oristano	Concluded in 2018	Installation of LED lamps as well as the unification of power supply systems and the definition of a Management Plan that allows rationalizing energy requirements.	0	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Governance
Management and maintenance of the port lighting service-ports of Olbia, Golfo Aranci Cocciani and Porto Torres.	2016-2019	Definition of a service for the management and ordinary and extraordinary maintenance of port lighting systems to improve energy efficiency and reduce the volume of atmospheric emissions in the port context.	1.4	Reduction of energy requirement and CO2 emissions.	Energy efficiency	Economic
RUMBLE	2018-2021	Supporting sustainability practices in the port domain for reducing noise pollution.	1.9	Reduction of noise emissions and related externalities to local communities and the environment.	Research and Development	Social
Safety interventions and maintenance in the port of Portovesme	Concluded in 2018	The intervention involves the replacement of the current lighting fixtures with new LED technology projectors along with the removal and rebuilding of electrical connections from the main power backbone to the individual lighting fixtures.	0.1	Improvement of energy efficiency and reduction of CO2 emissions.	Energy efficiency	Economic

Source: authors' elaboration