# ENVIRONMENTAL DISCLOSURE: STUDY ON EFFICIENCY AND ALIGNMENT WITH ENVIRONMENTAL PRIORITIES OF SPANISH PORTS

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**Abstract**

The purpose of this article is to analyze, in a three-stage research, the relationships between environmental expenses, the improvements achieved in 5 environmental variables analyzed and efficiency, from an economic and operational perspective. The stages of this research are analyzing the sustainability reports to determine the level of information, analyzing the economic and operational efficiency, and analyzing the alignment with the environmental priorities of the Eco Ports-ESPO (European Sea Ports Organization). The results reveal that (1) the type of traffic does not condition environmental actions; (2) environmental performance (improvements) depends on environmental expenditures; (3) environmental spending and efficiency in port operations are correlated; and (4) environmental spending and port economic efficiency are correlated.

**Keywords**: Environmental disclosure; Green port; Environmental indicators; Port efficiency; DEA

## 1. Introduction

Maritime transport is an important type of transport for globalized trade, as it takes approximately 90% of the global trade volume (Lun, 2013). However, its negative impacts on the environment are significant, hence the reason why ports should be taken into account in this scenario because there are large ecological interventions to enable this type of transport (Wang et al., 2020), such as air pollution, water quality, ballast water, dredging and disposal of dredge materials and storage, transport, and management of hazardous substances (Hiranandani, 2014). These impacts raise the need for an environmental management of ports, whose advantages may be related to customer satisfaction, corporate image, cost savings and environmental protection (Teerawattana & Yang, 2019).

Nonetheless, there is an important paradox, because even though the relevance of environmental management of ports is recognized (Bermúdez et al., 2019; Taliani et al., 2017) , the pressure to ensure competitiveness and globalization (Hervás-Peralta et al., 2020) represents a managerial stress. That is to say, there is the need to prioritize the environment as opposed to maintaining economic efficiency (Castellano et al., 2020; Dong et al., 2019) .

Given this scenario, the European Sea Ports Organization (ESPO) emphasizes the importance of controlling and monitoring green practices (Castellano et al., 2020). In particular, it identifies annually, through the EcoPort (EP) initiative, environmental priorities for European ports with the intention of encouraging environmental management practices. In 2019 EcoPort listed as priorities the following areas: Air quality, Energy consumption, Climate change, Noise, Relationship with the local community, Ship waste, Garbage/Port waste, Port development (long related), Dredging operations and Water quality.

What is known so far is that the sustainable port environment becomes viable with the active involvement of stakeholders and port operators through the implementation of key sustainable indicators (Eswari & Yogeswari, 2019). Studies have shown that economic efficiency achieves the ideal target when ports have a high pro-environmental attitude, implementing proactive green policies (Castellano et al., 2020). It is also recognized the importance of knowing about external pressures on issues related to environmental management (Bermúdez et al., 2019[a]; Kuznetsov et al., 2015) and economic efficiency (Dong et al., 2019; Castellano et al., 2020; Taliani et al., 2017).

However, the environmental priorities of ports can change annually (EcoPorts, 2020), since the environmental impact and social pressure on the adopted environmental posture may vary. This variation may occur both by normative aspects and by the pressure of interest groups (Bermúdez et al., 2019b) and by the profile of each port (size, type of cargo, and logistics, among others). This is due to the development of the port, as it can be greatly influenced by government policies and regulations, central planning, impact control and market uncertainty (Dong et al., 2019). This allows to identify environmental management priorities; identify the areas of high priority of common

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concern in which ports they are working, and define the guidance framework and initiatives that the PAs should take. (Puig et al., 2017).

The environmental sustainability of ports is at the same time relevant and complex. It is relevant because the environmental management of ports is recognized (Bermúdez et al., 2019; Taliani et al., 2017) , but there is still pressure to ensure competitiveness and globalization (Hervás-Peralta et al., 2020). In this context, this article proposes, in a three-stage research and from an economic and operational perspective, to analyze the relationships between environmental expenses, the improvements achieved in 5 environmental variables analyzed and the efficiency.

The study is justified by two perspectives, firstly by the alignment of ports with global environmental priorities (EcoPorts), and secondly by the economic and operational efficiency of the ports. In the first place the literature reveals that sustainable port development encompasses social, economic and environmental factors (Eswari & Yogeswari, 2019; Kuznetsov et al., 2015) . This sustainable development, including port operations and projects, means having a long-term vision, transparency, legal commitment, information exchange and innovation (Eswari & Yogeswari, 2019). However, we still have a challenging scenario that demonstrates the need to have a strategic and holistic vision, since the volume of cargo transported through ports is increasing, which increases environmental impacts. In addition, maritime trade has changed with more and modern ports, which also increases aspects of competitiveness (Taliani et al., 2017). Sustainability in port systems can be challenging and complex (Eswari & Yogeswari, 2019), as it integrates organizational aspects and the zone of influence of the port related to the environment, such as the preservation of the coast, morphology and marine biodiversity (Castellano et al., 2020), in addition to economic aspects that allow maintaining competitiveness at the global level (Taliani et al., 2017).

To support managers and society achieve sustainable development, aspects of environmental management and environmental indicators have helped identify, control and monitor environmental aspects and impacts (Rosa et al., 2019). The reason is that environmental management is used to identify, measure and manage environmental information (Rosa et al., 2012). Studies have revealed that to assist environmental management, indicators and metrics can be considered to control, monitor and verify information. Environmental indicators and port evaluation systems are important for measuring and monitoring issues related to policy, personnel, training, communication, monitoring and environmental auditing (Puig et al., 2017). They can reveal the various environmental dimensions, including, but not limited to, water consumption, water quality, carbon footprint, energy consumption, and auditing, in addition to enabling the setting for priorities and specific information for port development (Teerawattana & Yang, 2019; Kegalj et al., 2018; Roos & Kliemann Neto, 2017; Taliani et al., 2017; Lonsdale et al., 2015; Macková et al., 2019; Lonsdale et al., 2015). It can be useful mainly to define an overview of the position of the port sector and establish a performance that allows us to outline future trends (Puig et al., 2017), assisting in risk mitigation and environmental protection (Lonsdale et al., 2015), to make the business legitimate for stakeholders (Rosa, Bartolli and Lunkes, 2021). In this sense, our study is justified when it allows analyzing the alignment of environmental sustainability of Spanish ports with the priorities established by EcoPort.

The second justification of the study is the analysis of the economic and operational efficiency of the ports. Recent studies have investigated this complex factor through efficiency analysis instruments, such as Data Envelopment Analysis (DEA). The results of these studies are that the integration between economic efficiency and environmental performance of ports is important to improve economic value and to sustain the competitiveness of Port, having the environmental performance as the central point (Castellano et al., 2020; Gobbi et al., 2019; Dong et al., 2019; Taliani et al., 2017). The empirical results of these studies reveal that the DEA was used to analyze the efficiency of the ports and verify a positive relationship between environmental sustainability and economic performance.

Taliani et al (2017) analyzed the efficiency and environmental information of Spanish ports identifying which efficient and marginally efficient ports provided the best environmental disclosures. Gobbi et al., (2019) analyzed the environmental efficiency of Brazilian ports in relation to plastic waste management using the DEA technique, and discovered that efficiency is not

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consistent from one year to the next, which can occur due to flawed control practices and procedures, as well as inaccurate information about waste generated and discarded by each port. Castellano et al., (2020) identified that the developed critical activities, such as energy-saving programs, actions to reduce air and water pollution, and waste management contribute to improving environmental performance and economic efficiency at the same time. Wang et al., (2020) verified in the study on port efficiency using the DEA that the aspects of port cooperation can improve the expected overall production but will lose its advantage with the improvement of the standards of emissions.

Considering the proposed objective and the justifications presented, this article is thus organized in a presentation of the background and research hypotheses, materials and method, results, and discussion. Finally, we included the references used.

## 2. Materials and Method

### 2.1. Data Collection and Analysis

The purpose of this article is to analyze, in a three-stage research, the relationships between environmental expenses, the improvements achieved in 5 environmental variables analyzed and efficiency, from an economic and operational perspective. The objective is to characterize the following 24 out of the 28 Spanish Ports Authorities (PAs), based on the result of the analysis of the relationships aforementioned: A Coruña, Almería, Avilés, Bahía De Algeciras, Bahia De Cádiz, Baleares, Barcelona, Bilbao, Cartagena, Castellón, Ceuta, Ferrol-San Cibrao, Gijón, Huelva, Las Palmas, Málaga, Marín Y Ría De Pontev., Melilla, Motril, S. Cruz De Tenerife, Tarragona, Valencia, Vigo, Vilagarcía. The reference data for the study is 2018.

The purpose is to identify correlations among environmental improvements, and operational and economic efficiency of port management, with consideration of environmental expenses, traffic, and overheads structure. In the first stage of the research we analyzed the environmental memories of the 24 PAs, which were part of our sample, to quantitatively determine the improvements they had achieved in the 5 variables selected for the study: air quality, waste, fuel consumption, water consumption and electricity consumption. We also analyzed the type of information they provided of these variables in their environmental memories. Due to the existence of specific environmental regulations, the main traffic in the PAs was considered.

| Definition | Scale/items |
|---|---|
| Air quality - Type of information<br>Waste - Type of information<br>Fuel consumption - Type of information<br>Water consumption - Type of information<br>Electricity consumption - Type of information<br>Noise - Type of information | • No information<br>• Descriptive (D)<br>• Monetary (M)<br>• Quantitative (Q)<br>• Descriptive & Monetary (D&M)<br>• Descriptive & Quantitative (D&Q)<br>• Monetary & Quantitative (M&Q)<br>• Descriptive, Monetary & Quantitative (D, M & Q) |
| Environmental expenses/operating expenses<br>Air quality improvement<br>Water consumption improvement<br>Waste improvement<br>Electricity consumption improvement<br>Fuels consumption improvement<br>ROI | % |
| Main Traffic | • Liquid bulks<br>• Dry bulks<br>• General cargo<br>• Liquid bulks/general cargo<br>• Dry bulks/general cargo<br>• General cargo/passengers |

Table 1: Variables included in the first stage analysis and scales applied

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In the second stage of the study, an Economic and Operational Efficiency analysis was performed. A review of the literature on the efficiency of maritime ports shows that DEA is one of the most frequently used quantitative techniques (Wang et al., 2020; Dong et al., 2019; Gobbi et al., 2019; Taliani et al., 2017). Table 2 shows the variables applied in two analyses.

| Variables applied in the DEA economic analysis | |
|---|---|
| Inputs | Depreciation and amortization of non-current assets<br>Personnel Expenses<br>Other operating expenses |
| Output | Operating Revenue |
| **Variables applied in the DEA operational analysis** | |
| Inputs | Tangible Fixed Assets<br>Number of Employees<br>Total Operating Expenses |
| Outputs | Percentage of Concessional Occupation<br>Thousands of GT<br>TM of goods (Freight traffic) |

Table 2, Variables DEA

The third stage of the study involved a correlational analysis of the PAs environmental reporting found in the first stage, and an analysis of the results found in the second stage of the economic and operational efficiency. The purpose was to define and characterize environmental groups, based on the information related to environmental improvements and environmental expenditure obtained in the first stage, and compare it with the efficiencies reported by PAs. The data used in this analysis were obtained from the official periodical reports issued by each PA. The environmental evaluation, as well as the DEA economic and operational efficiency analysis, was administered to 24 PAs, which represent the 85.7% of Spanish ports of general interest. Therefore, this evaluation maintains its relevance. The Frontier Analyst software was used for the DEA analysis.

### 2.2. Research hypothesis

To assist the management of European ports the EcoPorts proposes methodologies for controlling and monitoring green practices (Castellano et al., 2020). The fundamental principle of EcoPorts is to create a level playing field regarding the environment through cooperation and knowledge shared between ports. EcoPorts provides two well-established tools to its members: Self-Diagnosis Method (SDM), and Port Environmental Review System (PERS), in addition to publicizing all year round, a list of environmental priorities of the Top 10. The update of Top l0's environmental issues is an important exercise, because it identifies the areas of high-priority common concern on which ports are working, and defines the framework for guidance and initiatives to be taken by representative bodies (Puig et al., 2017). However, the level of environmental expenditures, as well as the port's profile in terms of load, can influence performance (Taliani, Giralt and Rosa, 2017). We understand that the level of evidence on environmental priorities can facilitate implementing measures to manage environmental aspects; the first and second research hypothesis emerges:

*h1= the type of traffic conditions environmental actions*

*h2 = environmental performance (improvements) depends on environmental expenditures*

Previous studies have shown that port sustainability is complex, as it involves environmental and economic interests that go beyond the organizational setting. The studies also revealed that environmental aspects have become extremely important for the competitiveness of ports, and, consequently, integrating environmental performance and economic efficiency is more and more important, in order to improve economic value and to sustain the competitiveness of Port, considering environmental performance as the central point (Castellano et al., 2020; Gobbi et al., 2019; Dong et al., 2019; Taliani et al., 2017). From the context of this research, we understand that environmental performance leads to greater economic efficiency, thus emerges the third and fourth hypothesis of research:

*h3= environmental spending and efficiency in port operations are correlated*

*h4= environmental spending and port economic efficiency are correlated*

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**3. Results**

In the first stage of the investigation, a database was developed including the improvements (+ or -), as a percentage, analized by the 24 PAs in 2018. This type of information was collected through the environmental memories (according to the scale set out in Table 1).

In the second stage, we opted for a DEA efficiency analysis with variable returns to scale (Banker, Charnes y Cooper (BCC) model) using the variables previously defined. The model calculates the relative efficiency of each PA, including changes in operational scale to reflect the current reality of the PA comprising the Spanish Ports System. The study performed was designed based on maximum outputs, an essential efficiency factor. The potential actions on the expense structure and non-current assets of PAs is constrained, due to the nature of activity, as most PAs' overhead expenses are fixed. As noted above, the data used in this analysis were obtained from the official periodical reports issued by each PA. Table 3 shows the summary of the basic statistics of DEA variables for the period analyzed.

Table 3: Basics statistics – Inputs/Outputs

| | Operating Revenue | Personnel | Amortization | Other operating expenses |
|---|---|---|---|---|
| Average | 9,415,979.29 € | 13,505,957.75 € | 16,899,231.25 € | 47,991,864.04 € |
| Max. | 32,341,000.00 € | 45,588,000.00 € | 57,706,000.00 € | 180,326,000.00 € |
| Min. | 2,779,290.00 € | 1,539,858.00 € | 2,895,221.00 € | 5,056,759.00 € |
| S.D. | 6,690,252.93 € | 11,845,564.87 € | 13,895,955.70 € | 42,149,184.68 € |

| | Tangible Fixed Assets | Number of Employees | Total Operating Expenses | Percentage of Concessional Occupation | Thousands of GT | TM of goods (Freight traffic) |
|---|---|---|---|---|---|---|
| Average | 350,422,371.79 | 204.29 | 37,285,811.83 | 57.23 | 93,704,388.31 | 22,243,226.54 |
| max | 1,435,932,000.00 | 535.00 | 135,635,000.00 | 98.28 | 410,703,181.00 | 102,543,929.32 |
| min | 53,409,264.00 | 62.00 | 7,085,000.00 | 11.65 | 2,698,826.00 | 868,060.50 |
| S.D. | 319,124,662.11 | 115.94 | 30,217,728.81 | 20.38 | 116,675,483.17 | 25,076,961.18 |

The use of DEA analysis with variable returns to scale to maximize the outputs considered, gives as a result the classification of the efficiency assigned to the different units analysed, to which a value of 0% - 100% is assigned, and, thus the score assigned to efficient and inefficient PAs. (see Table 4). The assumptions applied in DEA analysis, were: scores below 100% indicate relative level of inefficiency.

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| Unit name | Economic DEA | | Operational DEA | |
|---|---|---|---|---|
| | Score (%) | RTS | Score (%) | RTS |
| A CORUÑA | 92.76 | 1 | 100.00 | 1 |
| ALMERÍA | 71.4 | -1 | 100.00 | -1 |
| AVILÉS | 90.46 | -1 | 50.10 | 1 |
| BAHÍA DE ALGECIRAS | 82.81 | 1 | 100.00 | 0 |
| BAHIA DE CADIZ | 64.61 | 1 | 66.50 | 1 |
| BALEARES | 100 | 1 | 87.30 | 1 |
| BARCELONA | 100 | 1 | 100.00 | 1 |
| BILBAO | 84.28 | 1 | 100.00 | 1 |
| CARTAGENA | 100 | 1 | 98.70 | -1 |
| CASTELLÓN | 100 | 1 | 100.00 | -1 |
| CEUTA | 100 | -1 | 100.00 | 0 |
| FERROL-SAN CIBRAO | 88.15 | -1 | 84.80 | -1 |
| GIJÓN | 100 | 1 | 64.67 | -1 |
| HUELVA | 91.81 | -1 | 90.10 | 1 |
| LAS PALMAS | 98.66 | 1 | 100.00 | 0 |
| MÁLAGA | 74.41 | -1 | 59.10 | -1 |
| MARÍN Y RÍA DE PONTEV. | 100 | -1 | 74.10 | 1 |
| MELILLA | 78.32 | -1 | 83.60 | -1 |
| MOTRIL | 100 | -1 | 100.00 | -1 |
| S. CRUZ DE TENERIFE | 82.57 | 1 | 100.00 | 0 |
| TARRAGONA | 88.97 | -1 | 100.00 | 0 |
| VALENCIA | 100 | 1 | 100.00 | 1 |
| VIGO | 82.55 | 1 | 58.20 | 1 |
| VILAGARCÍA | 100 | -1 | 100.00 | 0 |

Table 4: DEA Scores (2018)

The absolute score was divided among four categories: efficient PAs (score 100%), marginally efficient PAs ( ≥ 90%), marginally inefficient PAs ( ≥ 80%) and inefficient PAs (< 80%) as showed in Table 5.

```
ECONOMIC DEA

   Code   Meaning                              Frequency    %
  ------  ------------------------------------ ---------- -------
     1    Efficient                                 10    41.66
     2    Marginally Efficient                       3    12.50
     3    Marginally Inefficient                     7    29.16
     4    Inefficient                                4    16.66
                                               ---------- -------
                           Total                    24   100.00

OPERATIONAL DEA

   Code   Meaning                              Frequency    %
  ------  ------------------------------------ ---------- -------
     1    Efficient                                 13    54.16
     2    Marginally Efficient                       1     4.16
     3    Marginally Inefficient                     4    16.66
     4    Inefficient                                6    25.00
                                               ---------- -------
                           Total                    24   100.00
```

Table 5: PA classification by DEA Scores

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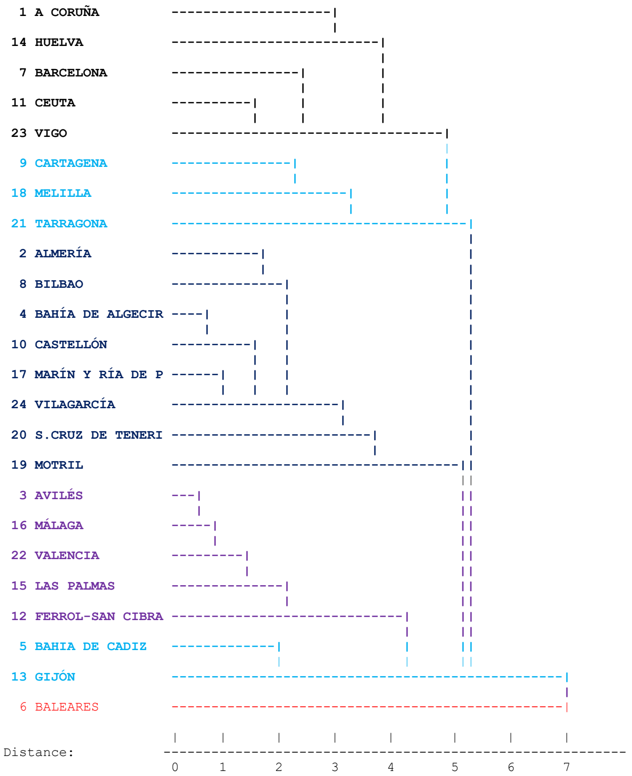
In the third stage of the study, a cluster analysis was performed. Group or cluster analysis techniques are statistical techniques serving to identify groups that, while otherwise different, are internally homogenous. We used the Johnson algorithm, full chain build-up, for all cluster analyses, in which the distance between two clusters (groups) is taken as the greatest between the elements integrating those groups. (Santesmases, 2005 pp.388).

The variables considered in the cluster analysis, used to classify PAs based on environmental improvements and expenses information, were the following: environmental expenses/operating expenses; air quality improvement; water consumption improvement; waste improvement; electricity consumption improvement; fuels consumption improvement. Table 6 contains the dendrogram obtained from this analysis, which shows the classification obtained of the PAs.




| Group | Nº | Code |
|---|---|---|
| 1 | 5 | 1 14 7 11 23 |
| 2 | 3 | 9 18 21 |
| 3 | 8 | 2 8 4 10 17 24 20 19 |
| 4 | 5 | 3 16 22 15 12 |
| 5 | 2 | 5 13 |
| 6 | 1 | 6 |

**Total sum of squares explained by clustering: 67,80%**

| | | TOTAL | GROUP 1 | GROUP 2 | GROUP 3 | GROUP 4 | GROUP 5 | GROUP 6 | ANOVA / F de Snedecor |
|---|---|---|---|---|---|---|---|---|---|
| | NUMBER: | 24 | 5 | 3 | 8 | 5 | 2 | 1 | |
| | Sum of squared: | 10.08 | 0.74 | 0.75 | 1.45 | 0.16 | 0.15 | 0.00 | |
| Variables: | | | | | | | | | |
| % enviro | Average: | 0.04 | 0.09 + | 0.01 - | 0.03 | 0.03 | 0.01 | 0.06 | F(5.18) = 4.2624 |
| | S.D.: | 0.04 | 0.04 | 0.00 | 0.02 | 0.02 | 0.01 | 0.00 | (p = 0.0099) |
| air impr | Average: | 0.11 | 0.15 | -0.03 | -0.06 - | -0.02 | 0.92 + | 0.76 | F(5.18) = 12.5028 |
| | S.D.: | 0.34 | 0.17 | 0.13 | 0.21 | 0.08 | 0.08 | 0.00 | (p = 0.0000) |
| water co | Average: | -0.03 | -0.33 | 0.11 | 0.09 | 0.05 | 0.17 + | -0.72 - | F(5.18) = 7.0843 |
| | S.D.: | 0.27 | 0.21 | 0.20 | 0.16 | 0.07 | 0.17 | 0.00 | (p = 0.0008) |
| waste i | Average: | 0.26 | 0.16 | 0.12 | 0.07 - | 0.72 + | 0.30 | 0.24 | F(5.18) = 16.3307 |
| | S.D.: | 0.27 | 0.10 | 0.23 | 0.09 | 0.04 | 0.17 | 0.00 | (p = 0.0000) |
| electric | Average: | 0.01 | -0.06 | -0.18 - | 0.08 | 0.03 | 0.01 | 0.13 + | F(5.18) = 2.4536 |
| | S.D.: | 0.14 | 0.13 | 0.10 | 0.13 | 0.03 | 0.05 | 0.00 | (p = 0.0731) |
| fuels im | Average: | 0.06 | 0.03 | 0.51 | -0.12 - | -0.02 | -0.11 | 1.00 + | F(5.18) = 4.6785 |
| | S.D.: | 0.37 | 0.22 | 0.36 | 0.29 | 0.14 | 0.08 | 0.00 | (p = 0.0065) |

Table 6: Dendrogram - PAs classification based on type of environmental information disclosed

## 4. Discussion

### 4.1. Descriptive analysis

The variables analyzed to evaluate the environmental actions that have been put in place by the various Spanish Ports Authorities are presented in the Table 7.

| |
|---|
| % Environmental expenses / Operating expenses |
| -Air quality |
| Waste |
| Fuels consumption |
| Water consumption |
| Electricity consumption |

Table 7. Variables used in the analysis

The variation experienced between 2017 and 2018 has been analyzed for each of these variables. The individual values obtained by the different PAs are not detailed in this article; instead the data has been analyzed using a Cluster analysis, which has allowed for the identification of 6 groups. Table 8 shows the variation rates achieved by each group in each of the variables mentioned above.

| | GROUP 1 | GROUP 2 | GROUP 3 | GROUP 4 | GROUP 5 | GROUP 6 | Average |
|---|---|---|---|---|---|---|---|
| % environmental expenses | 9% | 1% | 3% | 3% | 1% | 6% | **4%** |
| Air quality | 15% | -3% | -6% | -2% | 92% | 76% | **11%** |
| Waste | 16% | 12% | 7% | 72% | 30% | 24% | **26%** |
| Fuels consumption | 3% | 51% | -12% | -2% | -11% | 100% | **6%** |
| Water consumption | -33% | 11% | 9% | 5% | 17% | -72% | **-3%** |
| Electricity consumption | -6% | -18% | 8% | 3% | 1% | 13% | **1%** |

Table 8. Variation percentages for environmental variables

If these rates are analyzed, a well-defined behavior can be observed in the six groups. Group 6 stands out, as it shows an above-average environmental expenditure, which has translated into important above-average improvements in Air Quality, Fuels Consumption and Electricity Consumption. Despite achieving a major improvement in Waste, it is below average. On the contrary, Group 1 assembles the Ports Authorities that dedicates an above-average environmental expenditure and managed to improve both Air Quality and Waste. Group 5 only allocates 1% of its operation expenditure to environmental expenditure, although it achieves improvement ratios that are above the corresponding averages in Air Quality, Waste and Water Consumption. Group 3 and 4 allocate 3% of their operational expenditure to the environment achieving an above-average improvement in Water Consumption and Electricity Consumption. With regards to Group 2, its 1% environmental expenditure has allowed it to improve more than the average in Fuels Consumption and Electricity Consumption.

It is worth noting that the groups that have allocated a higher percentage of their expenditure to the environment have not managed to improve in Water Consumption. In the case of Group 6, which is an insular Port Authority, this can be caused by its high needs for this element and its reduced capacity to economize.

If the variation rates presented in Table 8 are compared to the variations shown by the Port Authorities (between 2017 and 2018) regarding the size of the ships that have circulated (measured in G.T. thousands) and good tonnes, a more discernible behavior can be observed. Figure 1 represents the variations observed in the activity levels of the six groups identified in the Ports Authorities between 2017 and 2018.

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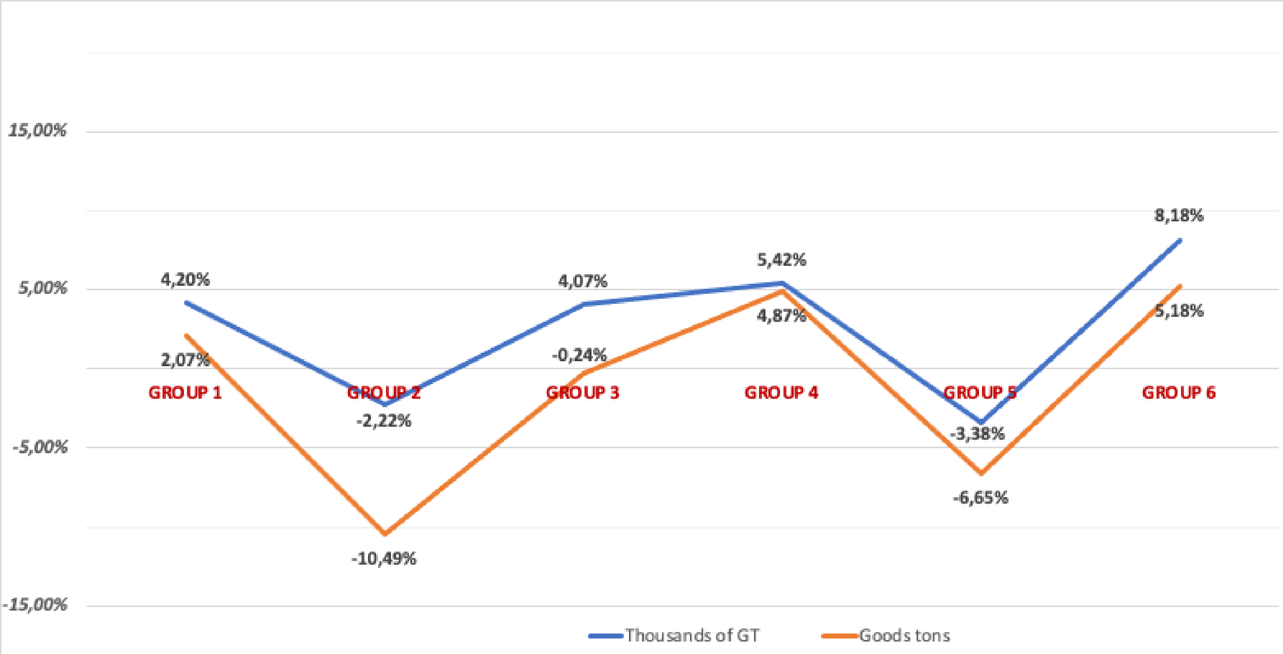

Figure 1. Variations in the activity levels of the Cluster Groups

Group 6 is the one that displays an increase in the port activity compared to the others, both in absolute numbers, regarding the average variations experienced by the G.T. and the Goods Tonnes. As for this, we can assert that despite the increase in the port activity, the improvements in the environmental variables are above the average, except for Water Consumption, which experiences the worst variation rate, as it did not achieve savings in the use of this resource.

Group 4 also experiences an economic activity variation rate above the corresponding averages, categorizing its environmental actions as very positive, except for the deterioration experienced in Air Quality, caused by a bigger number of ship movements, and Fuel Consumption. It is worth noting that in this Group are included two of the biggest Ports Authorities in containerized general cargo and one of the biggest ports in solid bulk, which results in more air pollution.

In Group 1 it is noted an increase in G.T. and Goods tonnes also above the corresponding averages. This group shows deterioration in Water Consumption and Electricity Consumption. In this group there can be found some of the Port Authorities that manage liquid bulk cargo which can be the cause preventing a savings increase in Water Consumption. However, the increase in Electricity Consumption is caused by the absence of measures to improve the efficiency when consuming this resource.

Group 3 shows a bigger movement of ships and a lower number of Goods tonnes. This can be the origin of deterioration in the Air Quality, although the lack of energy efficiency is obvious with regards to Fuels Consumption, as it has deteriorated over 2018. Groups 2 and 5 show a negative economic activity variation rate and display an uneven behavior in Air Quality and Electricity Consumption, which worsen in Group 2, even though Fuels Consumption worsens in Group 5.

Considering the information on the variables used in the group definition listed in Table 5 (previously analyzed) and the characterization of groups by traffic, reflected in Figure 2, data could be obtained that allowed contrasting the hypotheses 1 (*the type of traffic conditions environmental actions*) and 2 (*environmental performance -improvements- depends on environmental expenditures)*.

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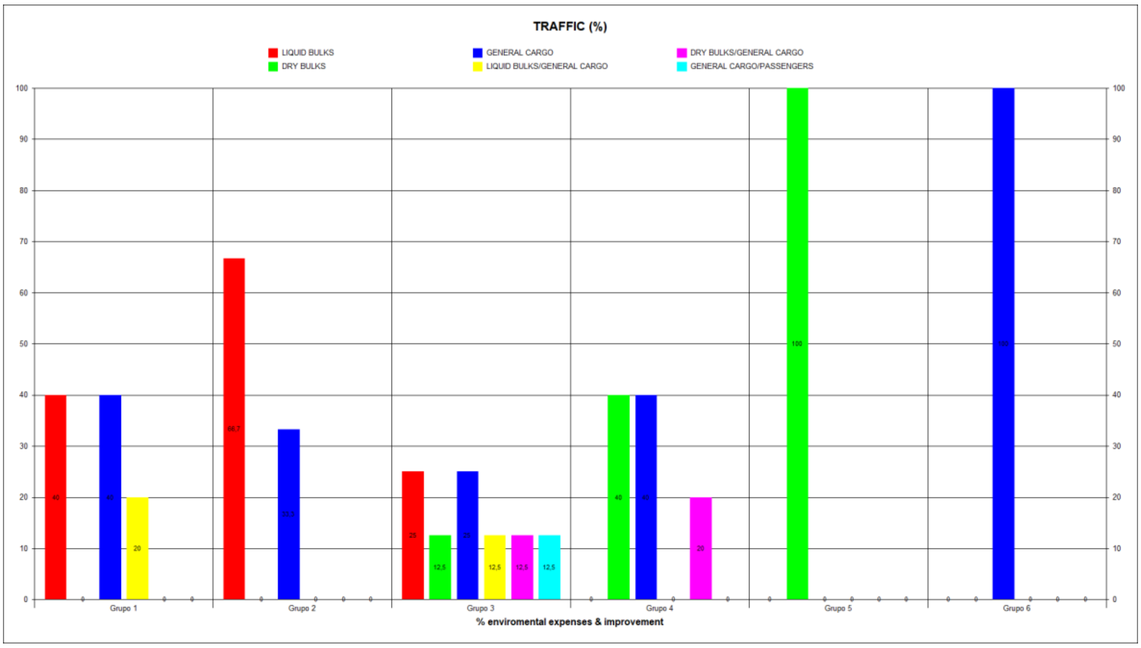

Figure 2. Traffic by group

What was verified in the port sector is that the type of cargo can be determinant for the type and level of environmental impact, that is, cargo considered dangerous (such as liquid cargo) is more likely to have environmental impacts. However, the results regarding the disclosure of environmental performance do not allow confirming the first hypothesis, because the groups with this load profile were not the ones that obtained the highest level of evidence. Based on the information presented, h1 hypothesis cannot be confirmed, whereas h2 can.

The characterization of the groups obtained, based on the two DEA analyses done and considering environmental variables (see table 9, 10 y 11) shows that group 1 which is the highest environmental expenditure is also the one that gets the best efficiency results calculated from the economic and operational variables. The behavior of groups 3 and 4, with an environmental expenditure of around 3%, is similar in terms of economic efficiency, but not in terms of operational efficiency. The lowest environmental expenditure groups, 2 and 5, are groups that show a higher level of operational and economic inefficiency, although both have members who are efficient from an economic perspective. Group 6, with a single PA, is an efficient group from an economic perspective, and marginally inefficient from an operational perspective (DEA score = 87.30%).

Based on the information presented, h3 hypotheses (*environmental spending and efficiency in port operations are correlated)* and h4 hypotheses (*environmental spending and port economic efficiency are correlated*) can be confirmed.

| | TOTAL | | cluster GROUP 1 | | GROUP 2 | | GROUP 3 | | GROUP 4 | | GROUP 5 | | GROUP 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEAOP_C | Frec | % | Frec | % | Frec | % | Frec | % | Frec | % | Frec | % | Frec | % |
| 1 Efficient | 13 | 54.17 | 3 | 60.00 | 1 | 33.33 | 7 | 87.50 | 2 | 40.00 | 0 | 0.00 | 0 | 0.00 |
| 2 Marginally Efficient | 2 | 8.33 | 1 | 20.00 | 1 | 33.33 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 3 Marginally Inefficient | 3 | 12.50 | 0 | 0.00 | 1 | 33.33 | 0 | 0.00 | 1 | 20.00 | 0 | 0.00 | 1 | 100.00 |
| 4 Inefficient | 6 | 25.00 | 1 | 20.00 | 0 | 0.00 | 1 | 12.50 | 2 | 40.00 | 2 | 100.00 | 0 | 0.00 |
| TOTAL | 24 | (24) | 5 | (5) | 3 | (3) | 8 | (8) | 5 | (5) | 2 | (2) | 1 | (1) |

Ji squared 15 degree of freedom = 23.8897 (p = 0.0670)

Table 9. Group by Operational variables DEA

| DEAECO_C | TOTAL Frec | TOTAL % | cluster GROUP 1 Frec | GROUP 1 % | GROUP 2 Frec | GROUP 2 % | GROUP 3 Frec | GROUP 3 % | GROUP 4 Frec | GROUP 4 % | GROUP 5 Frec | GROUP 5 % | GROUP 6 Frec | GROUP 6 % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Efficient | 10 | 41.67 | 2 | 40.00 | 1 | 33.33 | 4 | 50.00 | 1 | 20.00 | 1 | 50.00 | 1 | 100.00 |
| 2 Marginally Efficient | 4 | 16.67 | 2 | 40.00 | 0 | 0.00 | 0 | 0.00 | 2 | 40.00 | 0 | 0.00 | 0 | 0.00 |
| 3 Marginally Inefficient | 6 | 25.00 | 1 | 20.00 | 1 | 33.33 | 3 | 37.50 | 1 | 20.00 | 0 | 0.00 | 0 | 0.00 |
| 4 Inefficient | 4 | 16.67 | 0 | 0.00 | 1 | 33.33 | 1 | 12.50 | 1 | 20.00 | 1 | 50.00 | 0 | 0.00 |
| TOTAL | 24 | (24) | 5 | (5) | 3 | (3) | 8 | (8) | 5 | (5) | 2 | (2) | 1 | (1) |

Ji squared 15 degree of freedom= 11.5833 (p = 0.7103)

Table 10. Group by Economic variables DEA

| % environmental expenses (group average) | GROUP 1 | GROUP 2 | GROUP 3 | GROUP 4 | GROUP 5 | GROUP 6 |
|---|---|---|---|---|---|---|
| | higher average (9%) | lowest average (1%) | 3% | 3% | 1% | 6% |
| **DEA OPERATIONAL** | **60% efficient**<br>**20 % marginally efficient**<br>**20% inefficient** | **33.33% efficient**<br>**33.33% marginally inefficient**<br>**33.333% inefficient** | **87.5% efficient**<br>**12.5% efficient** | **40% efficient**<br>**20% marginally inefficient**<br>**40% inefficient** | **100% inefficient** | **100% marginally inefficient** |
| **DEA ECONOMIC** | **40% efficient**<br>**40 % marginally efficient**<br>**20% marginally inefficient** | **33.33% efficient**<br>**33.33% marginally inefficient**<br>**33.333% efficient** | **50% efficient**<br>**37.5% marginally inefficient**<br>**12.5% inefficient** | **20% efficient**<br>**40 % marginally efficient**<br>**20% marginally inefficient**<br>**20% inefficient** | **50% efficient**<br>**50% inefficient** | **100% efficient** |

Table 11. Group by efficiencies and environmental expenses

## 4.2.Environmental Disclosure and alignment with environmental priorities

The analysis of environmental disclosure is made from the elements considered a priority in EcoPorts2018. Although the EcoPorts system is complex in terms of environmental management, the individual data of the analyzed ports are not for public access. The information is consolidated and presented in the annual report without detailed information by port and performance of each element. Even with this limitation, the report allows the priorities established by European ports to be followed annually, as shown in Figure 3.


Figure 3. Top 10 EcoPorts2018
Source: EcoPorts (2020)

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In 2018, according to EcoPorts2018, the priorities of European ports were the following: (1) Air quality, (2) Energy consumption, (3) Noise, (4) Relationship with local community, (5) Ship waste, (6) Port development, (7) Climate change, (8) Water quality, (9) Dredging operations, and (10) Garbage/Port Waste.

This information comes from the self-assessment ports perform, that is later evaluated by EcoPorts. However, such information is not public. Nevertheless, the sustainability reports released by the ports do not necessarily highlight the information provided to EcoPorts. In this sense, this research identified that the information in the reports is not aligned with the elements of EcoPorts, as it presents general information on environmental performance. The elements highlighted in the reports are Air, Water, Noise, Waste, Energy, Fuel; as indicated in Table 12.

| **Type of environmental information** | **GROUP 1** | **GROUP 2** | **GROUP 3** | **GROUP 4** | **GROUP 5** | **GROUP 6** |
|---|---|---|---|---|---|---|
| **Traffics** | Liquid bulks General cargo Liquid bulks/general cargo | Liquid bulks General cargo | All types of traffic defined | Dry bulks General cargo Dry bulks/general cargo | Dry bulks | General cargo |
| Air (EcoPort 1) | 80% group information D&Q | 1/3 group D, 1/3 D&Q and 1/3 Q | 62.5 % group D&Q | 60% group D&Q | 100% group D&Q | 100% group D&Q |
| Energy (EcoPort 2) | 80% group information D&Q | 66.66% group Q | 50% group Q and 50% D&Q | 60% group D&Q | 100% group D&Q | 100% group D&Q |
| Noise (EcoPort 3) | 60% group information D&Q | 100% group D | 62.5 % group D&Q | 60% group no information | 50% group no information and 50% D&Q | 100% group D&Q |
| Waste (EcoPort 5) | 80% group information D&Q | 66.66% group D&Q | 50 % group D&Q | 60% group D&Q | 100% group D&Q | 100% group D&Q |
| Fuel (*EcoPort7) | 66% group Q | 1/3 group D, 1/3 D&Q y 1/3 Q | 50% group Q y 50% D&Q | 40% group D y 50% D&Q | 100% group D&Q | 100% group D&Q |
| Water (EcoPort 8) | 80% group D&Q | 66.66% group Q | 62.5 % group D&Q | 60% group D&Q | 100% group D&Q | 100% group D&Q |

Table 12. Port traffic and environmental performance

According to Table 12, some important issues may be observed, such as the alignment between the environmental priorities listed by EcoPorts taken from the responses of the ports to this organization system, and the sustainability reports issued by the ports to the public. The current investigation found that reports present information about 6 of the 10 priorities, emphasizing the 3 mains ones of the EcoPorts: Air, Energy and Noise. This may represent an alignment with EcoPorts and at the same time a search for legitimacy, as pointed out by the previous literature (Rosa, Bartolacelli and Lunkes, 2021).

It is also possible to verify that groups 1, 5 and 6 show greater amplitude in terms of dissemination, regarding information related to descriptive and quantitative data. However, this may represent a limitation of the scope and quality of information, because, according to previous literature, it is expected that the information disclosed on environmental aspects not only describes

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the situation of each element (Air, Energy, Noise, Waste, Ful and Water), but also is able to provide quantitative and monetary information. This demonstrates that the ports analyzed have not linked environmental issues to economic ones. This may limit information, which may also hinder that the different stakeholders understand the financial effort made to address the environmental issues of ports, as pointed out by the previous literature (Taliani, Giralt and Rosa 2017).

Some organizational aspects may lead to a higher or lower level of evidence (Bermúdez et al., 2019; Taliani et al., 2017), because the sustainability in port systems can be challenging and complex (Eswari & Yogeswari, 2019), as it integrates organizational aspects and the zone of influence of the port related to the environment, such as the preservation of the coast, morphology and marine biodiversity (Castellano et al., 2020), in addition to economic aspects that allow maintaining competitiveness at the global level (Taliani et al., 2017).

Additionally, it was verified that group 1, where all ports manage dangerous net cargo, included ports with the highest environmental expenditure. What may demonstrate that there is no disclosure, there are expenses necessary to manage performance or environmental impacts. However, the information about the expenditure is limited (without detailing the type of expenditure) which does not allow confirming the first hypothesis of this research. As shown in Table 4.

| **Environmental expenditures (E.S)** | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **Group 5** | **Group 6** |
|---|---|---|---|---|---|---|
| **% E.S.** | **9%** | **1%** | **3%** | **3%** | **1%** | **6%** |
| Air quality (EcoPort1) | 15% | -3% | -6% | -2% | 92% | 76% |
| Electricity (EcoPort2) | -6% | -18% | 8% | 3% | 1% | 13% |
| Fuel (EcoPort7) | 3% | 51% | -12% | -2% | -11% | 100% |
| Water (EcoPort8) | -33% | 11% | 9% | 5% | 17% | -72% |
| Waste (Ecoport10) | 16% | 12% | 7% | 72% | 30% | 24% |

Table 4. Evolution of the 2018 information in relation to the previous year and environmental performance

## 5. Conclusion

The purpose of this article is to analyze, in a three-stage research, the relationships between environmental expenses, the improvements achieved in 5 environmental variables analyzed and efficiency from an economic and operational perspective.

The objective is to characterize, the following 24 out of the 28 Spanish Ports Authorities (PAs), based on the result of the analysis of the relationships aforementioned: A Coruña, Almería, Avilés, Bahía De Algeciras, Bahia De Cádiz, Baleares, Barcelona, Bilbao, Cartagena, Castellón, Ceuta, Ferrol-San Cibrao, Gijón, Huelva, Las Palmas, Málaga, Marín Y Ría De Pontev., Melilla, Motril, S. Cruz De Tenerife, Tarragona, Valencia, Vigo, Vilagarcía. The reference data for the study is 2018. The purpose is to identify correlations among environmental improvements, operational and economic efficiency of port management, with consideration of environmental expenses, traffic, and overheads structure.

What was verified in the port sector is that the type of cargo can be determinant for the type and level of environmental impact, and that the results regarding the disclosure of environmental performance do not allow confirming the first hypothesis, because the groups with this load profile were not the ones that obtained the highest level of evidence. The characterization, based on the two DEA analyses completed, of the groups obtained considering environmental variables (see tables 9, 10 y 11) shows that environmental expenditures can influence the environmental performance in groups 3, 4 and 6, but the same cannot be affirmed for the other groups, which demonstrates that it is not conclusive that more expenses result in better performance, because other issues such as type of load can influence this performance.

The study reveals an alignment of the information provided by ports as relevant and environmental priorities listed by EcoPorts, taken from the responses of the ports to the EP system, and the sustainability reports issued by the ports to the public. The current research found that the reports present information about 6 of the 10 priorities, emphasizing the 3 main priorities of the EP: Air, Energy and Noise.

Even though an alignment was found with the priorities listed by EcoPorts and, although the ports studied showed economic and operational efficiency, as well as a relationship between environmental expenditures and environmental performance, we were also able to find limitations within the study. Firstly, it was not possible to identify the extension of the elements of environmental performance, since most of the information is descriptive and quantitative. Secondly, although we expected the type of cargo transported to be related to the environmental actions developed in the ports, it was not possible to verify this hypothesis in the ports analyzed.

For future research, it is considered relevant to analyze the role of coercive and voluntary elements regarding environmental dissemination and alignment with environmental priorities of international organizations.

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