Environmental disclosure and economic efficiency: A correlational evaluation of Spanish ports authorities

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Abstract

Purpose: Representative correlational study of Spanish Ports Authorities (PA), based on analysis of PA economic efficiency, measured using DEA Data Envelopment Analysis, and PA environmental disclosure. Data employed: environmental reports of 20 PAs examined to gain understanding of Environmental Disclosures; economic management reports of individual ports to obtain the economic variables analyzed. The purpose to identify correlations among variables of environmental disclosure and economic efficiency of port management, with consideration of port overheads and profit focused structure.

Design/methodology: A three-stage study, comprised of: 1st Classification of PAs efficiency; 2nd Analysis of environmental information disclosed, for which an Environmental Disclosure Assessment was defined; 3rd Cluster Analysis to determine correlations of the economic efficiency findings of stage 1 cross-referenced with environmental disclosures of stage 2.

Findings: The results obtained from the study are: classification of all Spanish PAs, although only 20 PAs are analyzed in stages 2nd and 3rd; snapshot of 2012 information contained in the Environmental Disclosure Assessment defined, and DEA with results of correlations between the PAs´ environmental disclosures and economic efficiency ratings. Among relevant findings, the study shows that Efficient and Marginally Efficient PAs provide best environmental

disclosures, as defined by type/frequency of reporting and environmental impact management information disclosed. Note: Efficient PAs provide more detailed information on water and energy management.

Research limitations/implications: 8 PAs not supplying environmental reports were excluded from stages 2-3, due to which final results do not include 100% of PAs of the Spanish port system.

Originality/value: The analysis allows to identify correlations among variables of environmental disclosure and economic efficiency of port management in Spanish Ports Authorities.

Keywords: Environmental Disclosure, Economic Efficiency, DEA (Data Envelopment Analysis), Ports

Jel Codes: C61, L92, M41

1. Introduction

Spanish Law 33/2010 (enacted 7 August 2010), contains a key aspect of the new legal framework regulating ports: the environmental components of port activity, which includes infrastructures, installations/facilities and services, all with potentially significant environmental impacts. The law considers environmental protection a responsibility of ports, and advocates the introduction of environmental management and sustainability mechanisms in Port Authority management.

In this regard, it should be noted that Port Authorities (hereinafter PAs) follow management models similar to those of private companies, designed to maximize income and optimize profits. Spanish Ports compete among themselves, and with other freight logistics and transport models for business, due to which achieving maximum economic efficiency is fundamental.

This paper proposes a dual perspective: economic efficiency, and environmental disclosure, an evaluation of port environmental management as it correlates to environmental reporting and economic results. The objective is to characterize PAs taking into account the two. The reference data for the study, taken from 2012, two years after enactment of Law 33/2010, provides insight on how PA Environmental Management Accounting and Reporting systems have responded since enactment of the law.

Numerous Environmental Accounting studies conducted in Spain (OECD, 2015; da Rosa, Lunkes, Pfitscher, Feliu & Soler, 2012) and abroad (Tanc & Gokoglan, 2015; KMPG, 2015; Burritt, 2012; Negash, 2012; Burnett & Hansen, 2008; Berthelot, Cormier & Magnan, 2003) document rising interest by companies in providing stakeholders with facts and figures on their environmental performance through the publication of annual sustainability reports.

Taking as reference the three main areas of research noted by da Rosa et al. (2012, pp. 29) in an exhaustive review of national and international literature on Environmental Accounting: Environmental Indicators, Environmental Disclosure or ED, and Fundamentals of Environmental Accounting, this study analyzes the correlations of environmental disclosure of PAs, with environmental performance, and economic performance.

Environmental indicators play an important role in the assessment and monitoring of environmental measures impacts. (Cerreta & Toro, 2012).

Among the many port-specific studies examining the subject are those of (Whitlam, 2013; Synnot, 2013; Giner, da Rosa, Lunkes, Ripoll & Crespo, 2012), on design of an Environmental Management System (EMS) for ports (U.S. EPA 2007), on improved port services quality through environmental regulation ((Bahauddin, 2014; Luttenberger, 2010), on cost-opportunity study of environmental regulation of PAs (Yang, 2013; Stojanovic, Smith & Wooldridge, 2006) on the impact of regulation on port management. The environmental efficiency of ports depends, to a great extent, on the environmental management of port concessionaires and other service providers, conducting activity within the port area. While Port Authorities do not have "legal" authority to sanction non-compliance by these actors intervening in Port functions, they do have the power to act via inclusion of environmental compliance requirements in tender specifications, operational guidelines, regulations, economic incentives, and supervision fees, among others (Puertos del Estado, 2012, pp. 66-67).

2. Research

As noted by Burnett and Hansen (2008, pp. 552), studies on Environmental Disclosure (hereinafter ED) have explored aspects such as: characteristics of the reporting entities, type of information reported, and the reasons that organizations opt to voluntarily disclose their environmental performance data. Researchers have also conducted comparative studies of the relationships (two by two) between: Environmental disclosure, environmental performance and economic performance.

The number of studies analyzing the relationships between environmental performance and the financial and economic performance of companies has also risen. Molina-Azorín, Claver-Cortés, López-Gamero and Tarí (2009), maintain that good environmental management generally has a positive impact on the financial performance of companies, and vice versa, referencing the previously mentioned quantitative studies of activity sectors, countries and settings (Ferrón, de la Torre & Aragón, 2010).

From an economic perspective, several studies have confirmed the importance of incorporating environmental aspects in port management, (sedimentation in aquatic environments, air emissions, waste generation, energy and water consumption and noise, among others),to guarantee better economic performance, affirming that improved environmental performance can reduce costs and enhance stakeholder engagement, with the ensuing positive economic results for the company (Poltrack, 2000; Kolk & Veen, 2002; Hou & Gerrlings, 2016).

As concluded by Al-Tuwaijri, Christensen and Hughes (2004), good environmental performance is associated, to a significant degree, with good economic performance, and also with more complete environmental disclosure and reporting. Thus, our research involved a descriptive, cross-cutting, 3-stage study of the year 2012, using Data Envelopment Analysis, to obtain a snapshot of the correlations between environmental disclosure by Ports Authorities and their economic efficiency.

A review of the literature on the efficiency of maritime ports shows that Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) are the quantitative techniques most frequently employed.

In this regard, we remit to the full review of the literature conducted by SchØyen and Odeck (2013, pp. 199-202), which documented that of 47 articles on port efficiency written between 1993 and 2008, 36 used DEA and 11 SFA, which, in the authors´ opinion shows that DEA Data Envelopment Analysis is the tool most frequently used, particularly in the most recent studies (Horgn-Jinh & Ling-Chu, 2012; Navarro & Zamora, 2014).

DEA arose as a welcome solution to a difficult need: calculating economic product cross-referenced with efficiency. DEA analyzes inputs and outputs and determines the relative efficiency of DMUs (Decision Making Unit: companies, strategic business units, processes and activities, among others) performing similar activities. In our study, the DMUs are the Ports Authorities of the Spanish Port System.

In the first stage of the study, a DEA analysis was done of all 28 Spanish Ports Authorities (46 ports managed), thereby ensuring that sample and evaluations of economic efficiency covered all members of the Spanish port system. The 20 PAs that had issued environmental reports were included in the second and third stages of the study.

We opted for a DEA efficiency analysis with variable returns to scale (Banker, Charnes and Cooper (BCC) model). In this model, the underlying hypothesis is that any variation of input to a DMU leads to a -not necessarily proportional- change in outcome. In other words, changes in scale affect efficiency. 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 for actions on the expense structure of PAs is constrained, due to the nature of activity, as most PA overhead expenses are fixed.

The data used in this analysis were obtained from the official periodical reports issued by the Assistant-Directorate of Management Analysis of the Public Entity Puertos del Estado.

2.1. Characteristics of the sample and variables used in the study

The DEA economic efficiency analysis was done for the entire population, the 28 PAs who represent the 46 Spanish ports of general interest. However, as mentioned earlier, in the environmental analysis the final sample is comprised only of the 20 PAs that publish environmental reports. Focusing the study in this way, over various stages, allowed us to determine a priori, the economic efficiency profile of the PAs not considered in the second stage of the study.

In the first stage of the study, an Economic Efficiency analysis was performed, with variables described as inputs and outputs. The variables applied in the DEA analysis are:

- Inputs

  - Depreciation and amortization of non-current assets

- ○ Personnel Expenses

- ○ Other operating expenses

- Outputs

- ○ Operating Revenue

Table 1 shows the summary of the basic statistics of these variables for the period analysed (in euros).

	Operating Revenue	Personnel Expenses	Amortization	Other operating expenses
Average	43,073,678.57	8,381,642.86	13,540,571.43	11,413,357.14
max	169,918,000.00	31,239,000.00	45,951,000.00	42,197,000.00
min	7,417,000.00	2,779,000.00	2,547,000.00	1,113,000.00
S.D.	39,031,428.39	5,910,328.72	11,312,381.65	10,223,583.63

Table 1. Basics statistics – Inputs/Outputs

For the second stage of the study, analysis of the environmental information disclosed by the PAs, an Environmental Disclosure Assessment was designed. The variables are detailed in Tables 2 and 3. The study included variables taken from the first stage of the study, that with DEA served to classify PAs in the following categories: efficient (score 100%), marginally efficient (≥ 90%), marginally inefficient (≥ 80%) and inefficient (< 80%).

Environmental Disclosure Assessment
1. ENVIROMENTAL MANAGEMETN POLICY (environmental aspects)
2. NATURAL RESOURCES MANAGEMENT
ENERGY
2.1.1. Type of information
2.1.2.1. Use of protocols
2.1.2.2. Disclosure years/periods
2.1.3.1. Energy Consumption reduction due to economic measures
2.1.3.2. Energy Consumption reduction due to efficiency measures
WATER
2.2.1. Type of information
2.2.2. Use of protocols
2.2.3. Disclosure years/periods
2.2.4.1. Annual volumes consumed from different sources
2.2.4.2. Verification
2.2.4.3. Water treatment method (explained)
2.2.5. Water reused and recycled (%)
3. ENVIRONMENTAL IMPACT MANAGEMENT
CO_2 EMISSIÓNS
3.1.1. Type of information
3.1.2. Use of protocols
3.1.3. Disclosure years/periods
3.1.4. Emissions affecting the ozone
3.1.5. Emissions of nitrous oxide (NO), sulphur oxide (SO) and other harmful substances
3.1.6.1. Annual targets
3.1.6.2. Future reductions of emissions
DISCHARGES
3.2.1. Type of information
3.2.2.1. Discharges treatment (%)
3.2.2.2 Treatment process
3.2.3. Annual targets
WASTE
3.3.1 SOLID WASTE
3.3.1.1. Type of information
3.3.1.2 Solid waste - Treatment processes
HAZARDOUS WASTE
3.3.2.1. Type of information
3.3.2.2 Treatment process
3.3.3. Annual targets
NOISE
3.4.1. Type of information
3.4.2. Annual targets

Table 2. Environmental Disclosure Assessment

Definition	Scale/items
1. Environmental Aspects in PAs reporting	• none • 1 aspect • 2 aspects • 3 aspects • 4 aspects • 5 aspects • 6 aspects • 7 aspects • 8 aspects • 9 aspects
2.1.1. Energy- Type of information 2.2.1. Water - Type of information 3.1.1. CO_2 emissions - Type of information 3.2.1. Discharges- Type of information 3.3.1.1. Solid waste -Type of information 3.3.2.1. Hazardous waste -Type of information 3.4.1. Noise -Type of information	• No information • Descriptive • Monetary • Quantitative • Descriptive & Monetary • Descriptive & Quantitative • Monetary & Quantitative • Descriptive, Monetary & Quantitative
2.1.2.1. Energy protocols 2.2.2. Water protocols 2.2.4.1. Annual volumes consumed from different sources 2.2.4.2. Water Verification 2.2.4.3. Water treatment method (explained) 3.1.2.CO_2 emissions protocols 3.1.4. Emissions affecting the ozone 3.1.5.Emissions of nitrous oxide (NO), sulphur oxide (SO) and other harmful substances 3.2.2.2 Discharges -Treatment processes 3.3.1.2 Solid waste - Treatment processes 3.3.2.2 Hazardous waste - Treatment processes	• No • Yes
2.1.2.2. Energy- Disclosure year/periods 2.2.3. Water- Disclosure year/periods 3.1.3. CO_2 emissions - Disclosure year/periods	• No data • Generic • Without specific period of time • Annual historical data • Data for periods of less than one year • 3 years of historical data
2.1.3.1. Energy Consumption reduction due to economic measures 2.1.3.2 Energy Consumption reduction due to energy efficiency measures 2.2.5. Water reused and recycled (%) 3.1.6.1. Emissions reduction annual targets 3.1.6.2. Future reductions of emissions 3.2.2.1. Discharges treatment (%) 3.2.3. Discharges –annual target 3.3.3. Hazardous waste - reduction target 3.4.2. Noise- annual target	• 0% • 25% or less • 50% or less • 75% or less • More than 75%
Economic DEA Score	Efficient Marginally efficient Marginally inefficient Inefficient

Table 3. Variables contained in the analysis and scales applied

3. Results

3.1. Results of the first stage

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.

Unit	Score
A CORUÑA	92,07
ALICANTE	70,49
ALMERÍA	64,41
AVILÉS	86,62
BAHÍA DE ALGECIRAS	100
BAHIA DE CADIZ	70,09
BALEARES	94,83
BARCELONA	100
BILBAO	74,35
CARTAGENA	100
CASTELLÓN	69,26
CEUTA	100
FERROL-SAN CIBRAO	84,76
GIJÓN	88,35
HUELVA	82,28
LAS PALMAS	90,77
MÁLAGA	61,96
MARÍN Y RÍA DE PONTEV.	100
MELILLA	76,22
MOTRIL	100
PASAJES	98,98
S.CRUZ DE TENERIFE	78,35
SANTANDER	54,77
SEVILLA	84,65
TARRAGONA	85,2
VALENCIA	100
VIGO	62,84
VILAGARCÍA	100

Table 4. DEA Scores - Economic Efficiency (2012)

The assumptions applied in DEA analysis, were: scores below 100% indicate relative level of inefficiency, inputs and outputs, with reference to the economic performance of the PA of the Spanish port system.

As noted earlier, the absolute score, reflected in Table 4, was divided among four categories: efficient PAs (score 100%), marginally efficient PAs (≥ 90%), marginally inefficient PAs (≥ 80%) and inefficient PAs (< 80%). In Table 4, the PAs not included in the environmental disclosure analysis are marked in red.The scores received in the first stage by the 8 PAs excluded from the second stage of the study

were: 2 efficient PAs (score 2), 1 marginally efficient PAs (≥ 1), 1 marginally inefficient PAs (≥ 1) 4 and inefficient PAs (< 4). Thus, the overall study refers to a sample representing 71.42% of the total population of Spanish PAs, and maintains its relevance.

Regarding the scores and categorization of the 20 PAs included in the stage 2: 30% are efficient, 15% marginally efficient, 25% marginally inefficient and 30% inefficient (Table 5).

```
ECONOMIC DEA

   Code   Meaning                            Frequency      %
   ------ ---------------------------------- ---------- -------
      1   Efficient                                  6   30,00
      2   Marginally Efficient                       3   15,00
      3   Marginally Inefficient                     5   25,00
      4   Inefficient                                6   30,00
                                             ---------- -------
                              Total                 20  100,00
```

Table 5. PA classification by DEA Scores

3.2. Results of the second stage of the study

Of the PAs examined in the second stage (those providing environmental reports and environmental disclosures) 85% included 5 or more environmental aspects in their reporting (Figure 1). The top 4 categories for which PAs provided descriptive and quantitative reporting (by percentage of PAs reporting on item) were: energy (50%); water and discharges (65%); solid and hazardous waste (75%); and 85% reported CO_2 emissions (Table 6).

In the reports examined, up to three years of historical data (the maximum breakdown) was supplied by PAs on the following items: CO_2 emissions (40% of PAs), water and energy, 50% and 55%, respectively (see Table 7).

Of these, all included information on energy management and CO_2 emissions protocols, with 85% reporting on water use protocols.

Regarding energy: none of the PAs in this category provided numbers (percentages of savings) on lower energy consumption, although 65% reported reductions of up to 25% due to energy efficiency measures.

85% of PAs reported on annual water volumes consumed from different sources; 70% of these Authorities have certified verification issued by independent experts. Regarding water treatment methods, while 95% of PAs explain the method used, only 35% supply data on the percentages of reused and recycled water (Table 8).

In the specific case of emissions, all PAs reported emissions affecting the ozone, emissions of nitrous oxide (NO), sulphur oxide (SO) and other harmful substances. 50% of the PAs cite annual emissions reduction targets of up 25%, and one PA has a 50% target.
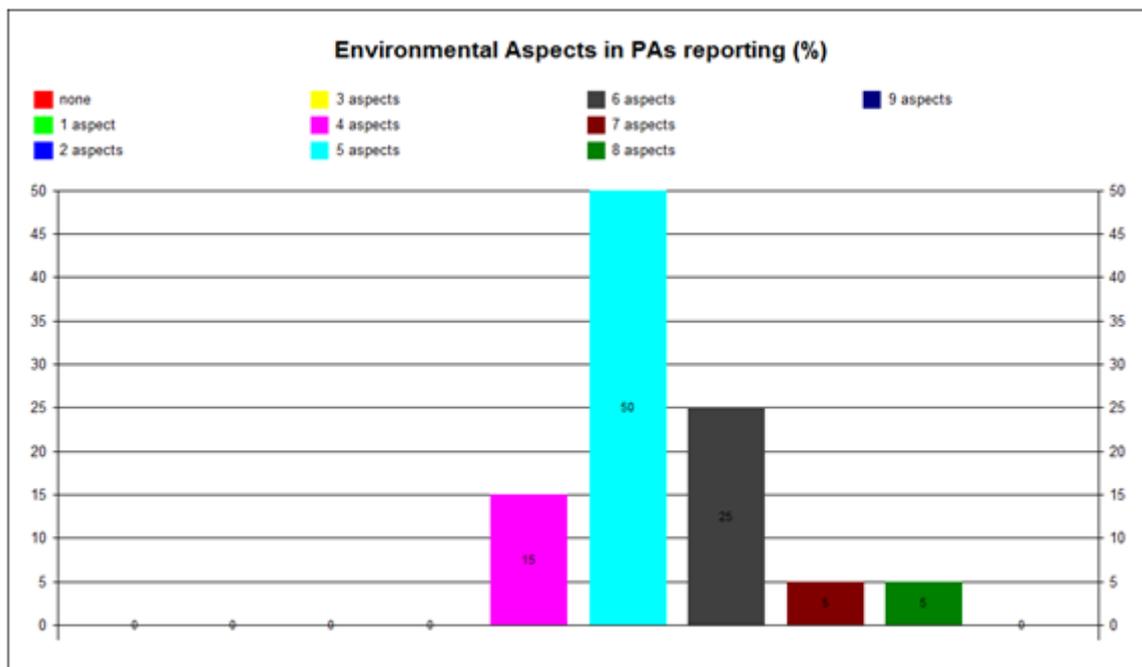
Figure 1. Environmental Management Policy

All of the PAs explain treatment processes for discharges, solid and hazardous wastes.65% of PAs report the percentage of discharges treated, although 50% set no future reduction or treatment targets (breakdown in Table 9). Regarding future reduction targets, 45% set no hazardous waste reduction target, and 75% no noise reduction target (Table 10).

```
2.1.1.   ENERGY Type of information

   Code   Meaning                              Frequency    %
   ------ ------------------------------------ ---------- -------
      4   Quantitative                                 3   15,00
      5   Descriptive & Monetary                       1    5,00
      6   Descriptive & Quantitative                  10   50,00
      7   Monetary & Quantitative                      2   10,00
      8   Descriptive, Monetary & Quantitative         4   20,00


                                              ---------- -------
                   Total                             20  100,00
```

```
2.2.1. Water Type of information

   Code   Meaning                              Frequency    %
   ------ ------------------------------------ ---------- -------
      2   Descriptive                                  2   10,00
      5   Descriptive & Monetary                       1    5,00
      6   Descriptive & Quantitative                  13   65,00
      7   Monetary & Quantitative                      1    5,00
      8   Descriptive, Monetary & Quantitative         3   15,00


                                              ---------- -------
                   Total                             20  100,00
```

```
3.1.1. CO2 Emissions Type of Information

   Code   Meaning                              Frequency    %
   ------ ------------------------------------ ---------- -------
      2   Descriptive                                  1    5,00
      5   Descriptive & Monetary                       1    5,00
      6   Descriptive & Quantitative                  17   85,00
      7   Monetary & Quantitative                      1    5,00
                                              ---------- -------
                   Total                             20  100,00
```

```
3.2.1. DISCHARGES Type of information

   Code   Meaning                              Frequency    %
   ------ ------------------------------------ ---------- -------
      2   Descriptive                                  2   10,00
      5   Descriptive & Monetary                       1    5,00
      6   Descriptive & Quantitative                  13   65,00
      7   Monetary & Quantitative                      2   10,00
      8   Descriptive, Monetary & Quantitative         2   10,00


                                              ---------- -------
                   Total                             20  100,00
```

```
3.3.1.1. SOLID WASTE Type of information

   Code   Meaning                                 Frequency     %
   ------ ------------------------------------    ----------  -------
     2    Descriptive                                    1      5,00
     5    Descriptive & Monetary                         1      5,00
     6    Descriptive & Quantitative                    15     75,00
     7    Monetary & Quantitative                        1      5,00
     8    Descriptive, Monetary & Quantitative           2     10,00


                                                 ----------  -------
                      Total                             20    100,00

3.3.2.1. HAZARDOUS WASTE Type of information

   Code   Meaning                                 Frequency     %
   ------ ------------------------------------    ----------  -------
     2    Descriptive                                    1      5,00
     5    Descriptive & Monetary                         1      5,00
     6    Descriptive & Quantitative                    15     75,00
     7    Monetary & Quantitative                        1      5,00
     8    Descriptive, Monetary & Quantitative           2     10,00


                                                 ----------  -------
                      Total                             20    100,00




3.4.1.NOISE Type of information

   Code   Meaning                                 Frequency     %
   ------ ------------------------------------    ----------  -------
     2    Descriptive                                    6     30,00
     5    Descriptive & Monetary                         1      5,00
     6    Descriptive & Quantitative                    12     60,00
     7    Monetary & Quantitative                        1      5,00
                                                 ----------  -------
                      Total                             20    100,00
```

Table 6. Type of environmental information disclosed

```
2.1.2.2.ENERGY disclosure year/period

Code    Meaning                                  Frequency      %
   ------ ------------------------------------ ---------- -------
     3    without specific period of time              5    25,00
     4    annual                                        4    20,00
     6    3 years of historical data                   11    55,00
                                               ---------- -------
                          Total                         20   100,00


2.2.3.WATER disclosure year/periods

Code    Meaning                                  Frequency      %
   ------ ------------------------------------ ---------- -------
     3    without specific period of time              7    35,00
     4    annual                                        3    15,00
     6    3 years of historical data                   10    50,00
                                               ---------- -------
                          Total                         20   100,00

3.1.3. CO2 EMISSIONS disclosure year/periods

Code    Meaning                                  Frequency      %
   ------ ------------------------------------ ---------- -------
     3    without specific period of time              6    30,00
     4    annual                                        6    30,00
     6    3 years of historical data                   8    40,00
---------- -------
                          Total                         20   100,00
```

Table 7. Frequency of environmental information disclosed

```
2.2.5. WATER reused y recycled (%)

   Code    Meaning                                Frequency      %
   ------ ------------------------------------ ---------- -------
     1    0%                                           13    65,00
     2    25% or less                                   4    20,00
     3    50% or less                                   3    15,00
                                               ---------- -------
                          Total                         20   100,00
```

Table 8. Percentages of reused and recycled water

```
3.2.2.1. DISCHARGES treatment (%)

Code   Meaning                                  Frequency    %
------ -------------------------------- ---------- -------
    1   0%                                         7    35,00
    2   25% or less                                4    20,00
    3   50% or less                                2    10,00
    4   75% or less                                6    30,00
    5   more than 75%                              1     5,00
                                         ---------- -------
                        Total                     20   100,00


3.2.3. DISCHARGES - annual target

Code   Meaning                                  Frequency    %
------ -------------------------------- ---------- -------
    1   0%                                        10    50,00
    2   25% or less                                3    15,00
    3   50% or less                                1     5,00
    4   75% or less                                5    25,00
    5   more than 75%                              1     5,00
                                         ---------- -------
                        Total                     20   100,00
```

Table 9. Discharges Management

```
3.3.3. HAZARDOUS WASTE - reduction target

   Code   Meaning                               Frequency    %
   ------ -------------------------------- ---------- -------
       1   0%                                        9    45,00
       2   25% or less                               5    25,00
       3   50% or less                               5    25,00
       4   75%  or less                              1     5,00
                                         ---------- -------
                        Total                     20   100,00

3.4.2. NOISE - annual target

Code   Meaning                                  Frequency    %
------ -------------------------------- ---------- -------
    1   0%                                        15    75,00
    2   25% or less                                2    10,00
    4   75% or less                                1     5,00
    5   more than 75%                              2    10,00
---------- -------
                        Total                     20   100,00
```

Table 10. Hazardous and Noise - reduction targets

3.3. Results of the third stage of the study

The third stage of the study involved a correlational analysis of the results of the economic efficiencies found in the first stage, and analysis of the PAs environmental disclosure reporting in the second stage. The objective was to characterize the efficiency groups found in the first stage, and compare it with the environmental disclosure information reported by PAs.

4 cluster analyses were 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 chainbuild-up*, for all cluster analyzes, in which distance between two clusters (groups) is taken as the greatest between the elements integrating those groups. (Santesmases, 2005, pp. 388).

The variables used in these analyses, and profile obtained for each of the groups is shown below.

3.3.1. PA groups: From analysis of type of environmental information disclosed

The variables considered in the first cluster analysis, done to classify PAs based on type of environmental information disclosed, and their economic efficiency rating in the first stage of the study were:

- 2.1.1. ENERGY Type of information

- 2.2.1. WATER Type of information

- 3.1.1. CO_2 EMISSIONS Type of information

- 3.2.1. DISCHARGES Type of information

- 3.3.1.1. SOLID WASTE Type of information

- 3.4.1. NOISE Type of information

- DEA Economic efficiency score

Table 11 contains the dendrogram obtained from this analysis, reflecting the classification obtained of the PAs.
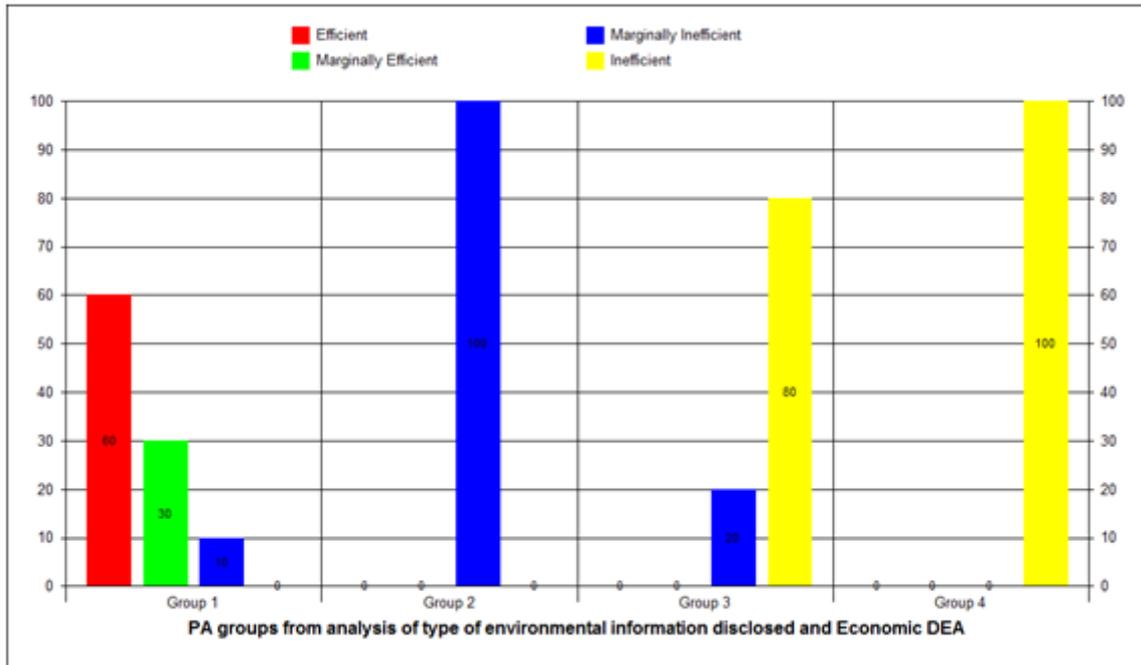
Figure 2. Efficiency distribution by group

Figure 2 shows efficiency distribution by group as determined via cross-tabulation of the previously defined efficiency categories and groups obtained in the first cluster analysis.

As shown in the figure, group 1 is the largest. It includes all PAs ranked as efficient (Bahía de Algeciras, Barcelona, Cartagena, Ceuta, Motril and Valencia); all ranked as marginally efficient (A Coruña, Las Palmas and Balearic Islands), and one PA (Gijón) ranked as marginally inefficient, which obtained the highest efficiency score (88.35%) among the marginally efficient PAs, placing it near the cut-off for the marginally efficient category. Group 2 is comprised of the marginally inefficient PAs with efficiency scores above 84% (Avilés, Ferrol and Tarragona). Group 3 includes four inefficient PAs with efficiency scores above 62% (Bilbao, Castellón, S. Cruz de Tenerife and Melilla) and one marginally inefficient PA (Huelva) that received the lowest efficiency score of its category. Group 4 includes the 2 PAs (Santander and Vigo), with the lowest economic efficiency scores, due to which both were ranked as inefficient.

```
  1 A CORUÑA        ----|
                        |
 11 GIJON          --| |
                     | |
 13 LAS PALMAS     -------|
                          |
  4 BALEARES       -------------|
                               |
  3 BAHÍA DE ALGECIR |          |
                    |          |
  7 CARTAGENA      ---|         |
                     |         |
 19 VALENCIA       -----|       |
                        |       |
 15 MOTRIL         ------|      |
  5 BARCELONA      |      |      |
                   |      |      |
  9 CEUTA          ------------------|
                                    |
  2 AVILÉS         ----|            |
                      |            |
 10 FERROL-SAN CIBRA -------|        |
                           |        |
 18 TARRAGONA      -----------------------------------------|
                                                           |
  6 BILBAO         -----|                                   |
                       |                                   |
  8 CASTELLON      -------------|                           |
                               |                           |
 12 HUELVA         ---|         |                           |
                     |         |                           |
 16 S. CRUE DE TENER -------|    |                           |
                           |    |                           |
 14 MELILLA        ----------------------------|           |
                                              |           |
 17 SANTANDER      ----------|                 |           |
                            |                 |           |
 20 VIGO           -------------------------------------------|

                   |   |    |    |    |    |    |    |    |    |    |
Distance           ----------------------------------------------------------
                   0   5   10   15   20   25   30   35   40   45   50


Group  N°    Code
-----  -----  ----------------------------------------------------------
 1     10     1  11  13   4   3   7  19  15   5   9
 2      3     2  10  18
 3      5     6   8  12  16  14
 4      2    17  20

Total sum of squares explained by clustering:           87,26%
```

Table 11. Dendrogram-PAs classification based on type of environmental information disclosed

In each of the groups, the variables showing significant average value differences are those related to the type of environmental information disclosed on water (variable 2.2.1), discharges (variable 3.2.1) and noise (3.4.1.).

Table 12 shows the cross-tabulation of the values of those variables, and the groups obtained. Thus, the group providing best quality information disclosure on water, discharges and noise is group 1, which includes all efficient and marginally efficient PAs. The group providing the poorest breakdown of environmental disclosure is group 2, which includes the majority of the marginally inefficient PAs. For the 3 variables mentioned above, it should be noted that groups 3 and 4, the inefficient PAs, provide a better breakdown in their disclosures than does group 2.

```
Rows: 2.2.1. Water Type of information
Columns: PA groups from analysis of type of environmental information disclosed and Economic
DEA
                              Type of information & Economic DEA
                              ------------------------------------------------
                   TOTAL      Group 1     Group 2     Group 3     Group 4
                   ----------  ----------- ----------- ----------- -----------
2.2.1. Water       Frec    %   Frec    %   Frec    %   Frec    %   Frec    %
----------------   ----  ------ ---- ------ ---- ------ ---- ------ ---- ------
 2 Descriptive      2  10,00    0   0,00    2  66,67    0   0,00    0   0,00
 5 Descriptive &    1   5,00    0   0,00    0   0,00    1  20,00    0   0,00
   Monetary
 6 Descriptive &   13  65,00    8  80,00    1  33,33    3  60,00    1  50,00
   Quantitative
 7 Monetary & Qua   1   5,00    1  10,00    0   0,00    0   0,00    0   0,00
   ntitative
 8 Descriptive,     3  15,00    1  10,00    0   0,00    1  20,00    1  50,00
   Monetary & Quan
                   ----  ------ ---- ------ ---- ------ ---- ------ ---- ------
       TOTAL       20   (20)   10   (10)    3   (3)    5   (5)    2   (2)

     Chi-squared  with 21 degrees of freedom = 18,5641    (p = 0,6131)



Rows:   3.2.1. DISCHARGES Type of information
Columns: PA groups from analysis of type of environmental information disclosed and Economic
DEA
                              Type of information & Economic DEA
                              ------------------------------------------------
                   TOTAL      Group 1     Group 2     Group 3     Group 4
                   ----------  ----------- ----------- ----------- -----------
3.2.1. DISCHARGES Frec    %   Frec    %   Frec    %   Frec    %   Frec    %
----------------   ----  ------ ---- ------ ---- ------ ---- ------ ---- ------
 2 Descriptive      2  10,00    0   0,00    2  66,67    0   0,00    0   0,00
 5 Descriptive &    1   5,00    0   0,00    0   0,00    1  20,00    0   0,00
   Monetary
 6 Descriptive &   13  65,00    8  80,00    1  33,33    3  60,00    1  50,00
   Quantitative
 7 Monetary & Qua   2  10,00    2  20,00    0   0,00    0   0,00    0   0,00
   ntitative
 8 Descriptive, M   2  10,00    0   0,00    0   0,00    1  20,00    1  50,00
   onetary y Quan
                   ----  ------ ---- ------ ---- ------ ---- ------ ---- ------
       TOTAL       20   (20)   10   (10)    3   (3)    5   (5)    2   (2)

     Chi-squared  with 21 degrees of freedom = 22,2308    (p = 0,3863)
```

```
Rows: 3.4.1.NOISE Type of information
Columns: PA groups from analysis of type of environmental information disclosed and Economic
DEA

                                      Type of information & Economic DEA
                                 ----------------------------------------------
                      TOTAL       Group 1      Group 2      Group 3      Group 4
                   -----------  -----------  -----------  -----------  -----------
3.4.1.NOISE        Frec    %    Frec    %    Frec    %    Frec    %    Frec    %
----------------   ----  -----  ----  -----  ----  ------  ----  -----  ----  -----
 2 Descriptive       6  30,00     2  20,00     3  100,00    0   0,00     1  50,00
 5 Descriptive &     1   5,00     0   0,00     0   0,00     1  20,00     0   0,00
   Monetary
 6 Descriptive &    12  60,00     7  70,00     0   0,00     4  80,00     1  50,00
   Quantitative
 7 Monetary & Qua    1   5,00     1  10,00     0   0,00     0   0,00     0   0,00
   ntitative
                   ----  ------  ----  ------  ----  ------  ----  ------  ----  ------
      TOTAL         20   (20)    10   (10)     3    (3)     5    (5)     2    (2)

      Chi-squared with 21 degrees of freedom = 13,3333    (p = 0,8965)
```

Table 12. Groups from analysis of type of environmental information disclosed

3.3.2. PA groups from analysis of frequency of environmental information disclosed

The second cluster analysis was to group PAs by years/periods of historic data provided in their environmental disclosures on consumption of natural resources and CO_2 emissions.

 The following variables were used.

- 2.1.2.2. ENERGY disclosure years/periods

- 2.2.3. WATER disclosure years/periods

- 2.2.3. CO_2 EMISSIONS disclosure years/periods

- DEA Economic Efficiency Score

Table 13 shows the PA groups defined and the members of each group.
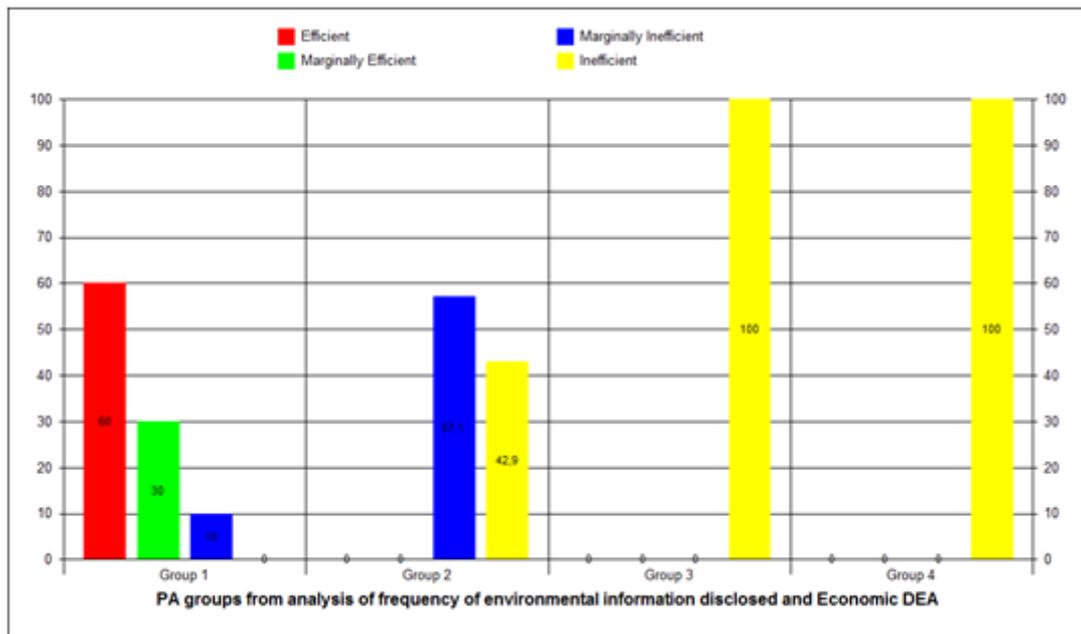
Figure 3. Distribution of efficiency by group

Figure 3 shows the distribution of efficiency by groups, as determined by cross-tabulating the previously defined efficiency categories and the groups obtained in this second cluster. In this analysis, group 1 once again includes the efficient PAs (Bahía de Algeciras, Barcelona, Cartagena, Ceuta, Motril and Valencia); the marginally efficient (A Coruña, Las Palmas and Balearic Islands), and one marginally inefficient PA (Gijón). Group 2 is comprised of the rest of the marginally inefficient PAs (Avilés, Ferrol-San Cibrao, Tarragona and Huelva), and of inefficient PAs having an efficiency score in their category above 74% (Bilbao, Melilla and S. Cruz de Tenerife). Groups 3 and 4 contain the remaining inefficient PAs (Castellón, Vigo and Santander).

```
1 A CORUÑA         --|
                     |
 4 BALEARES        --------|
                           |
11 GIJON           --|     |
                     |     |
13 LAS PALMAS      ------------|
                              |
 3 BAHÍA DE ALGECIR |         |
                    |         |
15 MOTRIL          -|         |
                    |         |
 9 CEUTA           -----|     |
                        |     |
 5 BARCELONA       -|   |     |
                    |   |     |
 7 CARTAGENA       ||   |     |
                   ||   |     |
19 VALENCIA        --------------------------|
                                             |
 2 AVILÉS          ---|                       |
                      |                       |
10 FERROL-SAN CIBRA |  |                      |
                    |  |                      |
18 TARRAGONA       ------|                    |
                         |                    |
12 HUELVA          ------------|              |
                              |              |
 6 BILBAO          ------|     |              |
                        |     |              |
14 MELILLA         -|   |     |              |
                    |   |     |              |
16 S. CRUZ DE TENER -----------------------------------------|
                                                            |
 8 CASTELLON       -------|                                  |
                         |                                  |
20 VIGO            ---------------|                          |
                                 |                          |
17 SANTANDER       -----------------------------------------|

Distance:          |   |    |    |     |    |    |    |    |    |   |
                   ----------------------------------------------------
                   0   5   10   15    20   25   30   35   40   45   50

Group   N°  Code
-----  ----- -------------------------------------------------------
  1     10    1   4  11  13   3  15   9   5   7  19
  2      7    2  10  18  12   6  14  16
  3      2    8  20
  4      1   17

Total sum of squares explained by clustering:        87,13%
```
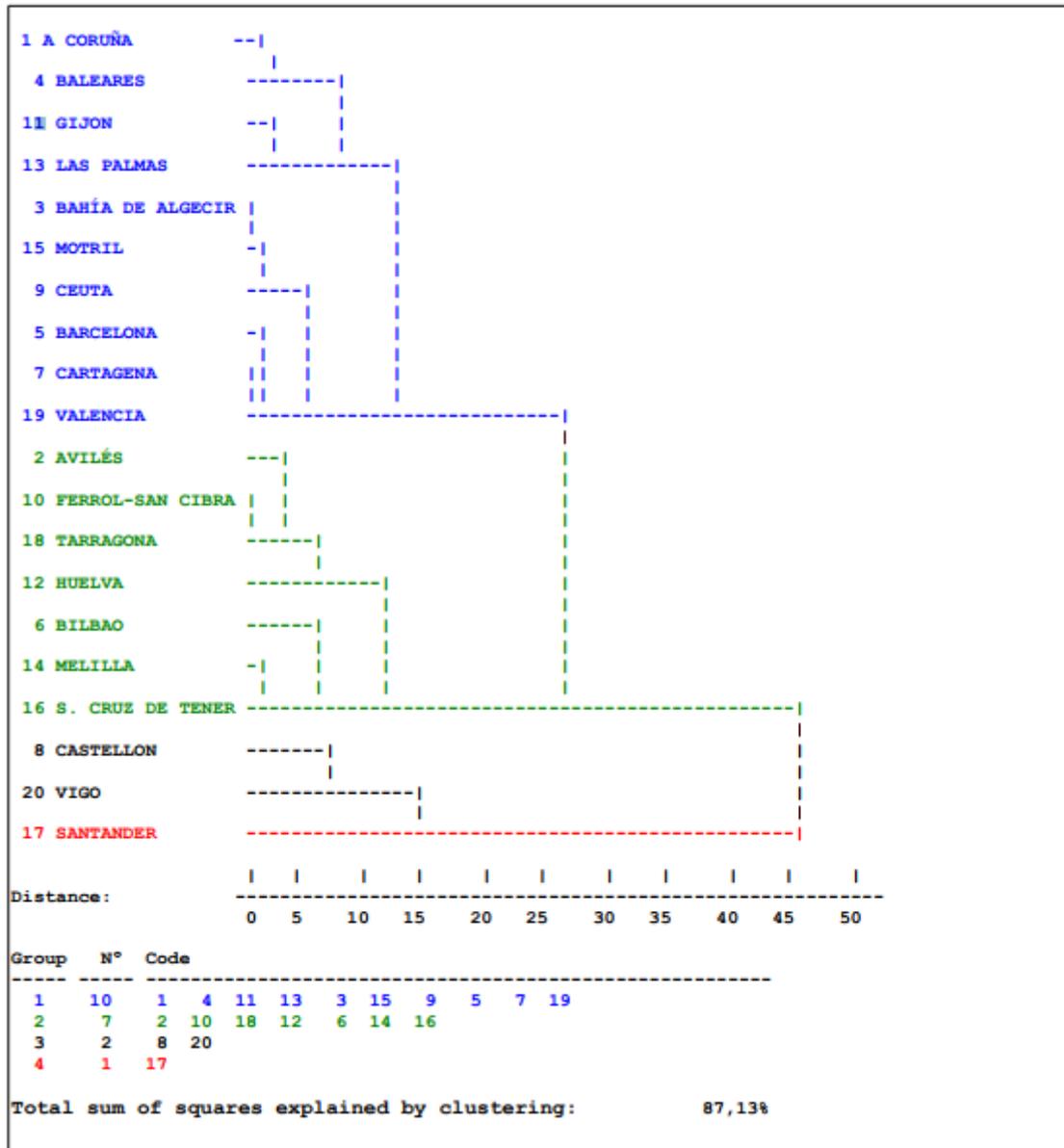
Table 13. Dendrogram- PAs groupsfrom analysis of frequency of environmental information disclosed

As seen in Table 14, groups 3 and 4, while those with the lowest efficiency ratings, reported the variables analyzed (energy, water and emissions) over the longest time-frames, annually or providing 3 years of historical data. A large proportion of the PAs included in groups 1 and 2 make no reference to specific time-frames in their disclosures on the three variables.

```
Rows: 2.1.2.2.ENERGY disclosure year/period
Columns: PA groups from analysis of frequency of environmental information disclosed and
Economic DEA
                Frequency of environmental information disclosed and Economic DEA
                       --------------------------------------------
                   TOTAL        Group 1      Group 2      Group 3      Group 4
                 -----------  -----------  -----------  -----------  -----------
2.1.2.2.ENERGY   Frec    %    Frec    %    Frec    %    Frec    %    Frec    %
---------------- ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
 3 without specif  5   25,00    3   30,00    2   28,57    0    0,00    0    0,00
   ic period of t
 4 annual          4   20,00    2   20,00    1   14,29    1   50,00    0    0,00
 6 3 years of his 11   55,00    5   50,00    4   57,14    1   50,00    1  100,00
   torical data
                 ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
     TOTAL        20    (20)   10    (10)    7    (7)     2    (2)     1    (1)

     Chi-squared with 15 degrees of freedom = 2,5286    (p = 0,9999)

Rows:    10. 2.2.3.WATER disclosure year/periods
Columns: 45. PA groups from analysis of frequency of environmental information disclosed and
Economic DEA

                Frequency of environmental information disclosed and Economic DEA
                       --------------------------------------------
                   TOTAL        Group 1      Group 2      Group 3      Group 4
                 -----------  -----------  -----------  -----------  -----------
2.2.3.WATER      Frec    %    Frec    %    Frec    %    Frec    %    Frec    %
---------------- ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
 3 without specif  7   35,00    3   30,00    4   57,14    0    0,00    0    0,00
   ic period of t
 4 annual          3   15,00    2   20,00    0    0,00    1   50,00    0    0,00
 6 3 years of his 10   50,00    5   50,00    3   42,86    1   50,00    1  100,00
   torical data
                 ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
     TOTAL        20    (20)   10    (10)    7    (7)     2    (2)     1    (1)

     Chi-squared with 15 degrees of freedom ad = 5,6735    (p = 0,9847)

Rows:    17. 3.1.3. CO2 EMISSIONS disclosure year/periods
Columns: 45. PA groups from analysis of frequency of environmental information disclosed and
Economic DEA
                Frequency of environmental information disclosed and Economic DEA
                       --------------------------------------------
                   TOTAL        Group 1      Group 2      Group 3      Group 4
                 -----------  -----------  -----------  -----------  -----------
3.1.3.CO2 EMISS  Frec    %    Frec    %    Frec    %    Frec    %    Frec    %
---------------- ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
 3 without specif  6   30,00    3   30,00    3   42,86    0    0,00    0    0,00
   ic period of t
 4 annual          6   30,00    3   30,00    1   14,29    2  100,00    0    0,00
 6 3 years of his  8   40,00    4   40,00    3   42,86    0    0,00    1  100,00
   torical data
                 ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
     TOTAL        20    (20)   10    (10)    7    (7)     2    (2)     1    (1)

     Chi-squared with 15 degrees of freedom = 7,1429    (p = 0,9536)
```

Table 14. Frequency of environmental information disclosed

3.3.3. PA classification by environmental impact management

The third cluster analysis was to classify PAs by the annual reduction targets each had cited for high environmental impact activities. The variables considered were the following:

- 3.1.6.1. EMISSIONS REDUCTION annual targets

- 3.2.3. DISCHARGES annual targets

- 3.3.3. HAZARDOUS WASTE reduction targets

- 3.4.2. NOISE annual targets

- DEA Economic Efficiency Score

The dendogram (Table 15), shows the results of this cluster analysis.
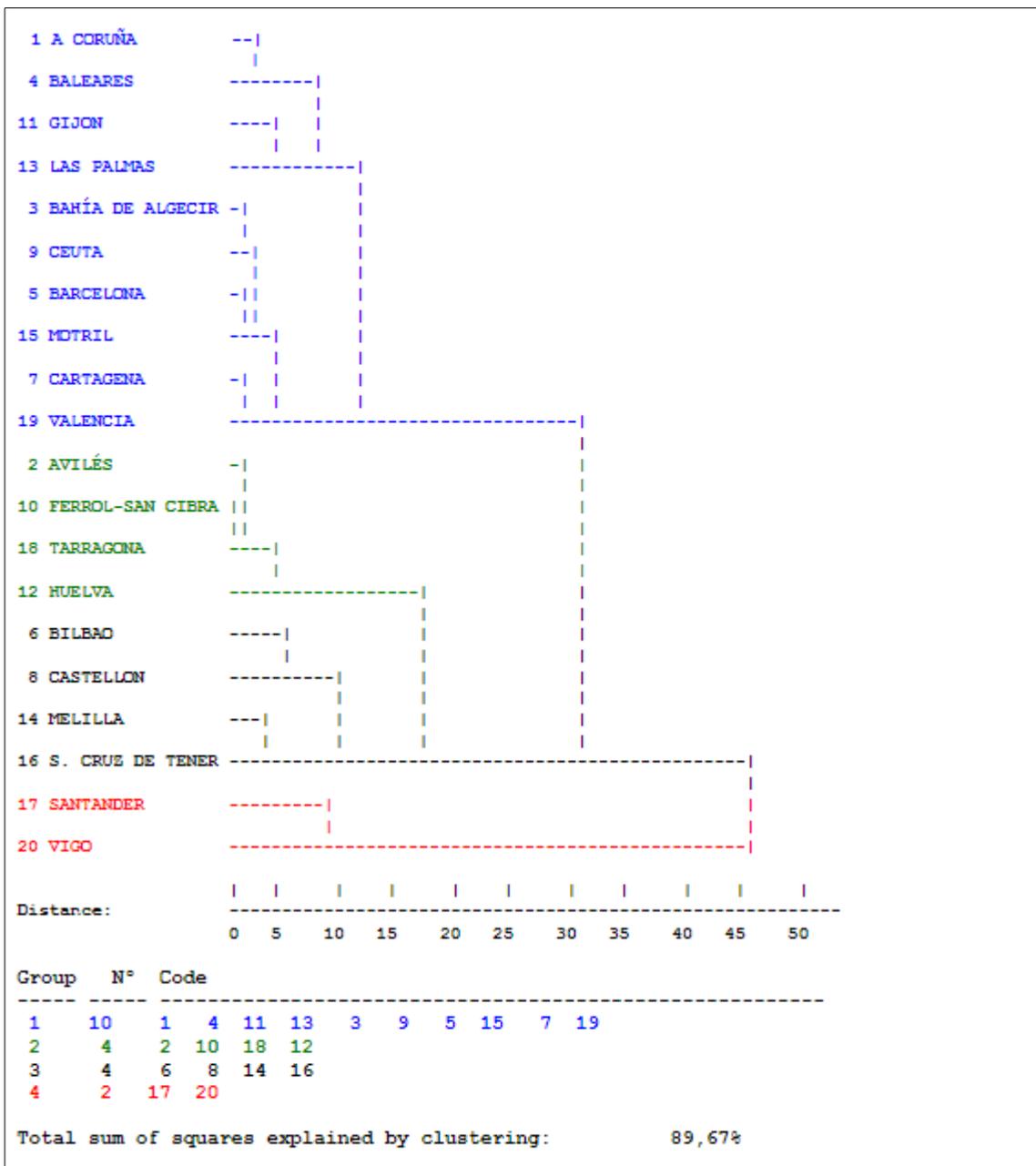
Table 15. Dendogram – PA classification by environmental impact management

Figure 4 shows the efficiency distribution of each of the groups, obtained in the cluster analysis. As in the previous clusters, group 1 contains all of the efficient and marginally efficient PAs, and the one marginally inefficient PA, (Gijón) which is included due to highest efficiency score within its group. In group 2 are the remaining marginally inefficient PAs. Groups 3 and 4 are comprised of the inefficient PAs. Group 3: Bilbao, Castellón, Melilla and S. Cruz de Tenerife and group 4: Santander and Vigo.
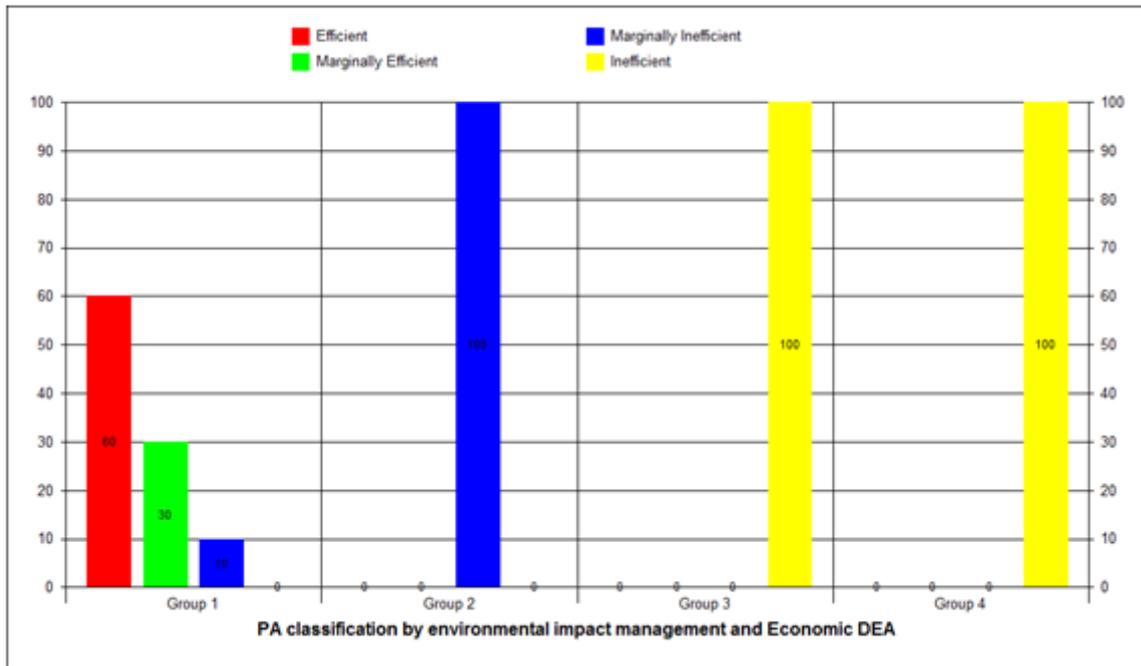

Figure 4. Distribution of efficiency by group

As reflected in Table 16, of group 1 PAs, 70% have established reduction targets for emissions, discharges and hazardous waste. Remarkably, none (0%) of group 2 PAs have set any emissions reduction target for the variables considered.

```
Rows:  3.1.6.1. EMISSIONS REDUCTION - annual target
Columns: PA classification by environmental impact management and Economic DEA

                      environmental impact management and Economic DEA
                      ------------------------------------------------
              TOTAL       Group 1      Group 2      Group 3      Group 4
            ----------  -----------  -----------  -----------  -----------
3.1.6.1.    Frec    %   Frec    %    Frec    %    Frec    %    Frec    %
----------- ---- ------ ---- ------- ---- ------- ---- ------- ---- -------
1 0%           9  45,00    3  30,00    4 100,00    2  50,00    0   0,00
2 25% or less 10  50,00    7  70,00    0   0,00    1  25,00    2 100,00
3 50% or less  1   5,00    0   0,00    0   0,00    1  25,00    0   0,00
            ---- ------ ---- ------- ---- ------- ---- ------- ---- -------
      TOTAL   20  (20)    10  (10)     4   (4)     4   (4)     2   (2)

      Chi-squared with 12 degrees of freedom = 12,4111   (p = 0,4133)
```

```
Rows:  3.2.3. DISCHARGES - annual target
Columns: PA classification by environmental impact management and Economic DEA

                          environmental impact management and Economic DEA
                          ---------------------------------------------
                 TOTAL       Group 1     Group 2     Group 3     Group 4
                 -----------  -----------  -----------  -----------  -----------
3.2.3. DISCHARGES Frec   %    Frec   %    Frec   %    Frec   %    Frec   %
----------------- ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
 1 0%             10  50,00    3  30,00    4 100,00    2  50,00    1  50,00
 2 25% or less     3  15,00    3  30,00    0   0,00    0   0,00    0   0,00
 3 50% or less     1   5,00    1  10,00    0   0,00    0   0,00    0   0,00
 4 75%  or less    5  25,00    2  20,00    0   0,00    2  50,00    1  50,00
 5 more than 75%   1   5,00    1  10,00    0   0,00    0   0,00    0   0,00
                  ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
     TOTAL        20  (20)    10  (10)    4   (4)     4   (4)     2   (2)

     Chi-squared with 12 degrees of freedom = 10,4000    (p = 0,5809)

Rows:  3.3.3. HAZARDOUS WASTE -  reduction target
Columns: PA classification by environmental impact management and Economic DEA

                          environmental impact management and Economic DEA
                          ---------------------------------------------
                 TOTAL       Group 1     Group 2     Group 3     Group 4
                 -----------  -----------  -----------  -----------  -----------
3.3.3. HAZARDOUS  Frec   %    Frec   %    Frec   %    Frec   %    Frec   %
----------------- ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
 1 0%              9  45,00    3  30,00    4 100,00    1  25,00    1  50,00
 2 25% or less     5  25,00    3  30,00    0   0,00    1  25,00    1  50,00
 3 50% or less     5  25,00    3  30,00    0   0,00    2  50,00    0   0,00
 4 75% or less     1   5,00    1  10,00    0   0,00    0   0,00    0   0,00
                  ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
     TOTAL        20  (20)    10  (10)    4   (4)     4   (4)     2   (2)

     Chi-squared with 12 degrees of freedom = 8,7556    (p = 0,7237)

Rows:  3.4.2. NOISE - annual target
Columns: PA classification by environmental impact management and Economic DEA

                          environmental impact management and Economic DEA
                          ---------------------------------------------
                 TOTAL       Group 1     Group 2     Group 3     Group 4
                 -----------  -----------  -----------  -----------  -----------
3.4.2. NOISE     Frec   %    Frec   %    Frec   %    Frec   %    Frec   %
----------------- ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
 1 0%             15  75,00    6  60,00    4 100,00    3  75,00    2 100,00
 2 25% or less     2  10,00    2  20,00    0   0,00    0   0,00    0   0,00
 4 75%  or less    1   5,00    0   0,00    0   0,00    1  25,00    0   0,00
 5 more than 75%   2  10,00    2  20,00    0   0,00    0   0,00    0   0,00
                  ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
     TOTAL        20  (20)    10  (10)    4   (4)     4   (4)     2   (2)

     Chi-squared with 12 degrees of freedom = 8,8000    (p = 0,7199)
```

Table 16. Environmental impact management

Noise management is the variable most neglected by all 4 groups. Only 40% of PAs within group 1 and 25% of group 3 have established noise reduction targets.

3.3.4. PA classification by natural resources management

The fourth and final cluster analysis (Table 17) was to classify PAs by management of the natural resources used. The variables used to build these groups were:

- 2.1.3.2. ENERGY CONSUMPTION reduction due to energy efficiency measures (% over previous reporting period)

- 2.2.5. WATER reused and recycled (%)

- DEA Economic Efficiency Score

```
 1 A CORUÑA              |
                         |
13 LAS PALMAS         ---|
                          |
11 GIJON           -------|
                          |
 2 AVILÉS           -|     |
                    |     |
10 FERROL-SAN CIBRA ||     |
                    ||     |
18 TARRAGONA        ----------------|
                                    |
 3 BAHÍA DE ALGECIR |               |
                    |               |
 9 CEUTA            |               |
                    |               |
19 VALENCIA        -|               |
                    |               |
 7 CARTAGENA       -|               |
                    |               |
 5 BARCELONA        ||              |
                    ||              |
15 MOTRIL           -----|          |
                         |          |
 4 BALEARES         ------------------------|
                                            |
 6 BILBAO           --|                     |
                      |                     |
14 MELILLA          --------|               |
                            |               |
12 HUELVA           ---|    |               |
                       |    |               |
16 S. CRUZ DE TENER ----------------------------------------------|
                                                                  |
 8 CASTELLON        -------|                                      |
                           |                                      |
20 VIGO             ---------------|                              |
                                   |                              |
17 SANTANDER        ---------------------------------------------|

            |   |    |    |    |    |    |    |    |    |    |
Distance:   ----------------------------------------------------------
            0   5    10   15   20   25   30   35   40   45

Group   N°  Code
-----  -----  -----------------------------------------------------
  1      6    1  13  11   2  10  18
  2      7    3   9  19   7   5  15   4
  3      4    6  14  12  16
  4      3    8  20  17

Total sum of squares explained by clustering:          93,63%
```
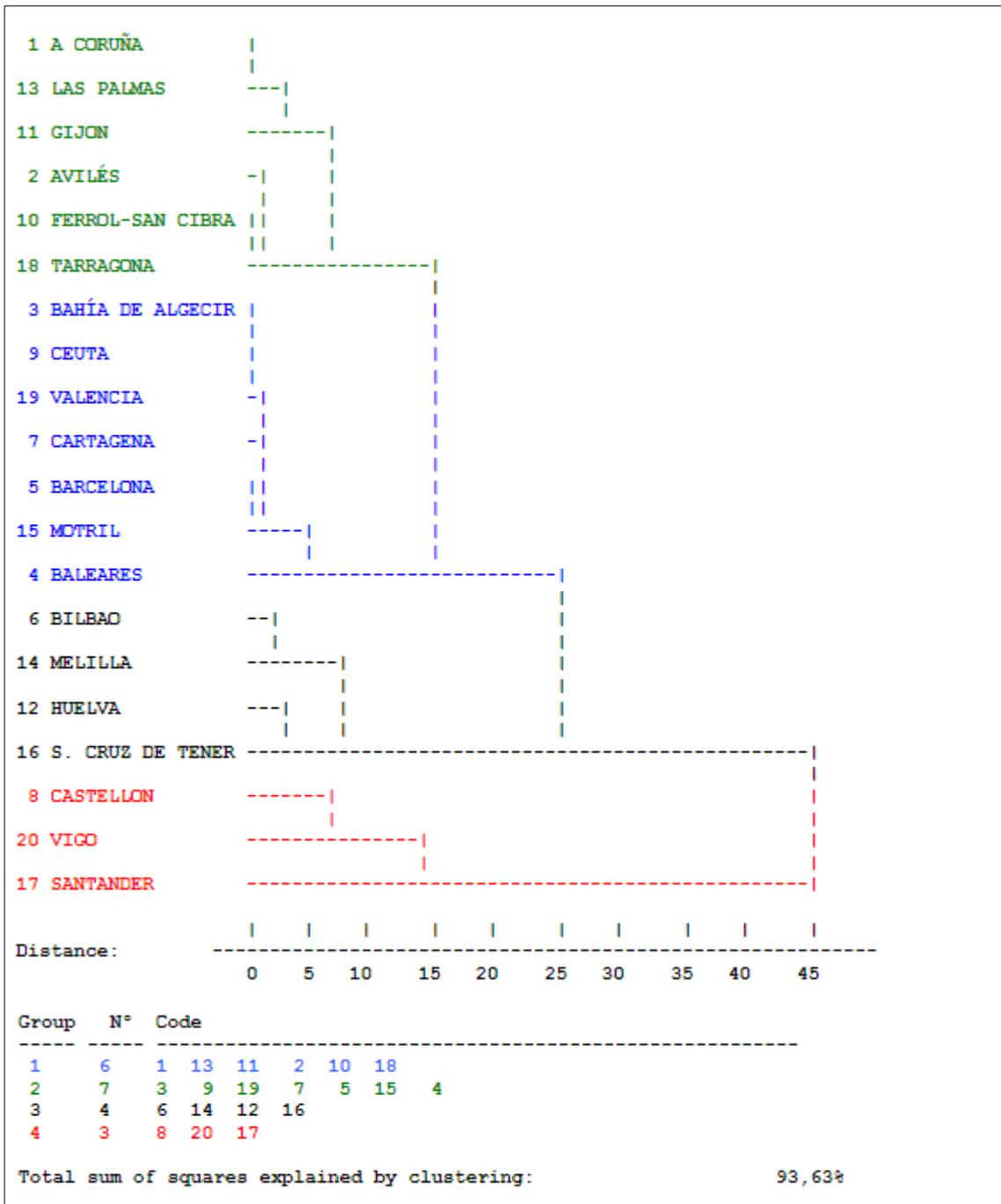
Table 17. Dendrogram - PA classification by natural resources management

As shown in Figure 5, group 1 is comprised of PAs considered marginally efficient (A Coruña and Las Palmas) and marginally inefficient (Avilés, Ferrol-San Cibrao, Gijón and Tarragona). Group 2 is comprised of efficient PAs (Bahía de Algeciras, Barcelona, Cartagena, Ceuta, Motril and Valencia) and includes one marginally efficient PA (Balearic Islands) due to highest efficiency score in its category (94,83%). Group 3 is comprised of marginally inefficient PAs with lowest efficiency scores (Bilbao, Melilla, Huelva and S Cruz de Tenerife). Group 4 is comprised of the most inefficient PAs (Castellón, Vigo and Santander).
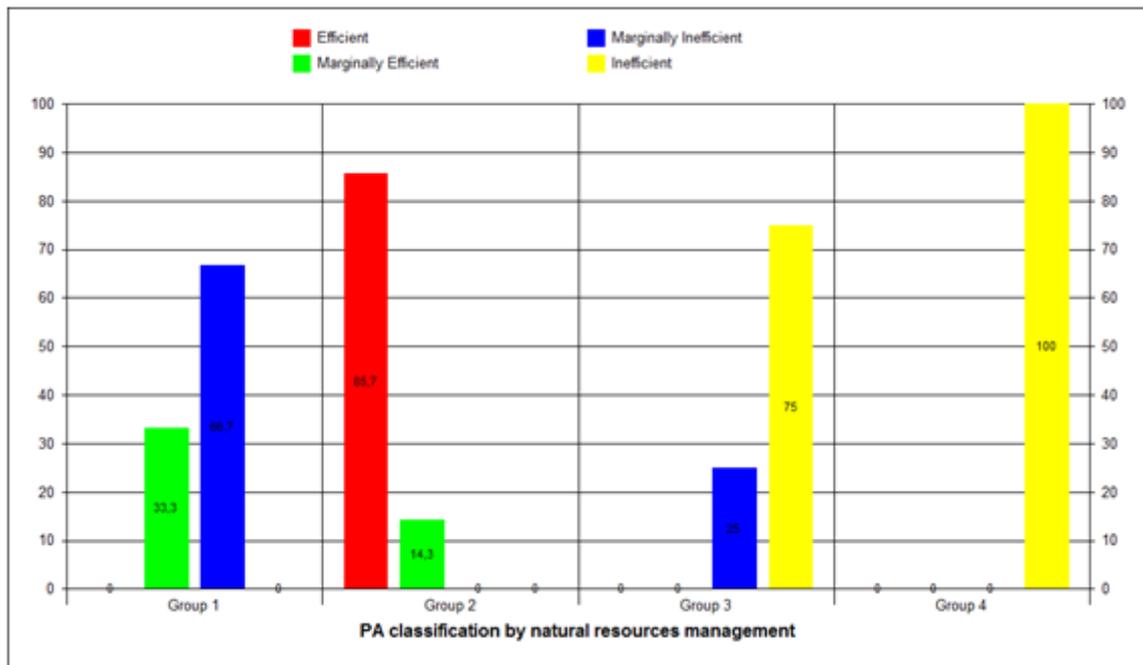
Figure 5. Distribution of efficiency by group

```
Rows:    2.1.3.2. ENERGY CONSUMPTION reduction due to energy efficiency measures (% over
previous reporting period)
Columns: PA classification by natural resources management

    natural resources management
                        ------------------------------------------------
                    TOTAL     Group 1     Group 2     Group 3     Group 4
----------- ----------- ----------- ----------- ----------- -----------
2.1.3.2. ENERGY Frec   %   Frec   %   Frec   %   Frec   %   Frec   %
---------------- ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
 1 0%              7 35,00    3 50,00    1 14,29    2 50,00    1 33,33
 2 25% or less    13 65,00    3 50,00    6 85,71    2 50,00    2 66,67
                  ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
    TOTAL         20 (20)     6 (6)      7 (7)      4 (4)      3 (3)

Chi-squared with 12 degrees of freedom = 2,3129    (p = 0,9988)

Rows:    2.2.5. WATER reused y recycled (%)
Columns: PA classification by natural resources management

natural resources management
                        ------------------------------------------------
                    TOTAL     Group 1     Group 2     Group 3     Group 4
            ----------- ----------- ----------- ----------- -----------
2.2.5. WATER    Frec   %   Frec   %   Frec   %   Frec   %   Frec   %
---------------- ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
 1 0%             13 65,00    6 100,00   3 42,86    3 75,00    1 33,33
 2 25% or less     4 20,00    0 0,00     3 42,86    1 25,00    0 0,00
 3 50% or less     3 15,00    0 0,00     1 14,29    0 0,00     2 66,67
                  ---- ------ ---- ------ ---- ------ ---- ------ ---- ------
    TOTAL         20 (20)     6 (6)      7 (7)      4 (4)      3 (3)

Chi-squared with 12 degrees of freedom = 12,7030    (p = 0,3910)
```

Table 18. Energy and water management

Table 18 reflects the % of PAs that, due to environmental management practices, have achieved improvements in their consumption of energy, and of reused/recycled water. Of these, group 2 (among the most efficient) contains the greatest percentage of PAs (85%) to achieve energy efficiency related reductions of up to 25%, and also reports the highest percentage of water reuse and recycling. The results of Group 4, the least efficient PAs, deserves mention here. Of these, 66% report energy efficiency improvements of up to 25%, and reused/recycled water improvements of up to 50%.Improvement percentages are lower for the PAs in groups 1 and 2, with 50% reporting improved energy consumption and 0%- 25% reporting improvements in water reuse/recycling, respectively.

4. Conclusions and future lines of research

73.34% of efficient PAs report on five or more environmental management aspects in their environmental disclosures, a figure that rises to 100% for marginally efficient PAs, and moves to 80% and 83.33%, for the marginally inefficient and the inefficient PAs, respectively (see Table 19).

```
Rows:    1. Environmental Aspects in PAs reporting
Columns: 35. ECONOMIC DEA


                                          Econ DEA
                        ------------------------------------------------
                TOTAL   Efficient Marginally Marginally Inefficient
              Efficient Inefficient
----------    ------------ ----------- ----------- -----------
POLITICA       Frec   %    Frec    %   Frec    %   Frec    %   Frec    %
------------  ----  ------  ----  ------ ----  ------ ----  ------ ----  ------
  4 aspects     3  15,00    1  16,67    0   0,00    1  20,00    1  16,67
  5 aspects    10  50,00    4  66,67    2  66,67    2  40,00    2  33,33
  6 aspects     5  25,00    0   0,00    0   0,00    2  40,00    3  50,00
  7 aspects     1   5,00    0   0,00    1  33,33    0   0,00    0   0,00
  8 aspects     1   5,00    1  16,67    0   0,00    0   0,00    0   0,00
----  ------  ----  ------ ----  ------ ----  ------ ----  ------ ----  ------
    TOTAL      20   (20)    6   (6)     3   (3)     5   (5)     6   (6)

Chi-squared with 27 degrees of freedom = 13,6889    (p = 0,9841)
```

Table 19. Economic efficiency and environmental management

However, in three of the four cluster analyses, all efficient and marginally efficient PAs are grouped together, which means the environmental reporting of these PAs was similar in terms of type and frequency/periods for data supplied on emissions, discharges, hazardous waste and noise. The inefficient and the marginally inefficient PAs with relatively lower efficiency scores, are also grouped together.

Tables 20 and 20b summarize the results of the four cluster analyses that enable us to characterize the PAs by environmental efficiency cross-referenced with their environmental management disclosures. Efficient and marginally efficient PAs are those providing the highest level of detail regarding the management of water, discharges and noise; 70% of the PAs in these groups also provide annual information on energy, water, CO_2 emissions and set reduction targets for discharges, hazardous waste and emissions. These are also the only PAs that establish noise reduction targets.

Efficient and marginally efficient	Marginally inefficient	Inefficient and marginally inefficient (lowest scores)
Cluster analysis: Information type		
WATER		
80% of PAs provide descriptive/quantitative data, and 10% also provide economic.	33% provide descriptive and quantitative	50%-60% of PAs (depends on group) provide descriptive/quantitative data and 2 also provide economic.
DISCHARGES		
80% of PAs provide descriptive/quantitative data, and 10% also provide economic.	33% provide descriptive and quantitative	50%-60% of PAs provide descriptive/quantitative data and 2 also provide economic.
NOISE		
70% provide descriptive and quantitative.	100% provide only descriptive.	50%-80% provide descriptive and quantitative.

Table 20. Summary of results by efficiency category

Cluster analysis: frequency and historic		
ENERGY		
70% provide annual or historic up to 3 yrs.	71% provide annual or historic up to 3 yrs.	100% provide annual or historic up to 3 yrs.
WATER		
70% provide annual or historic up to 3 yrs.	42% provide annual or historic up to 3 yrs.	100% provide annual or historic up to 3 yrs.
CO$_2$ EMISSIONS		
70% provide annual or historic up to 3 yrs.	42% provide historic up to 3 yrs.	100% provide annual or historic up to 3 yrs.
Cluster analysis: environmental impact management		
CO2 EMISSIONS		
70% set emissions reduction targets.	None reports emissions reduction targets	50%-100% set emissions reduction targets
DISCHARGES		
70% include emission reduction targets	None set emissions reduction targets	50% set emissions reduction targets
HAZARDOUS WASTE		
70% set hazardous waste reduction targets	None set hazardous waste reduction targets	50% - 70% set hazardous waste reduction targets.
NOISE		
40% set noise emissions reduction targets	None reports any noise emissions reduction targets	Inefficient PAs do not establish noise emissions reduction targets

Table 20b. Summary of results by efficiency category

Efficient PAs also stand out for their water and energy management. 85% reported reductions in energy consumption of up to 25%, and 57% also report the percentages of water recycled and reused.

Within the study, the environmental disclosure practices of the marginally inefficient PAs were poorest: none set environmental impact management targets for any of the 4 items, CO$_2$ emissions, discharges, hazardous waste or noise. They provide solely descriptive information, which fits with the data that only 33% of the PAs of this category provided descriptive and quantitative information on water and discharge management.

Regarding water and energy management, the marginally efficient and the marginally inefficient PAs have similar environmental reporting behaviours: 50% of these report reduced energy consumption, but do not report percentages of water recycled or reused.

Here it should be noted that the inefficient and marginally inefficient PAs (with lowest scores in their category) consistently provide higher levels of detail in their disclosures than, at least, 50% of the PAs. They usually provide descriptive and quantitative data, and set targets for emissions, discharges and hazardous waste. 100% provide annual information and/or up to 3 years historic. Regarding energy and water management, 50%-66% of the inefficient PAs report energy consumption reductions of up to 25%.Further, between 25% and 66% of the PAs report the percentages of recycled and reused water.

General observations: the most economically efficient PAs are those that provide the fullest environmental disclosure data on the four environmental reporting indicators considered: type, frequency, environmental impact, and water and energy management, as was concluded by Al-Tuwaijri et al. (2004). The results of the study show that the most economically efficient PAs do a better job of managing the environmental impact of their energy and water use.

The results of this study of Spanish Port Authorities echo the findings of a study done of 10 major U.S. ports (Cheon, Maltz & Dooley, 2017), which found that economic performance is linked to good environmental management and practices, and good environmental management has become a competitive advantage for ports. The U.S. and Spain have both amended existing port legislation to include requirements on the environmental sustainability of port operations, while not losing sight of the economic fact that ports are businesses.

Spanish law 33/2010 will most assuredly be followed by further environmental regulations and requirements for ports. We feel that the Spanish Ports Authorities should consider adopting Integrated Reporting Models in anticipation of events. This would enable Spanish ports to gradually improve their environmental reporting on financials, economic resources dedicated and governance, while also serving to inform stakeholders of their environmental performance, resource consumption, plans, targets and risk/opportunity strategies. As noted by Castilla and Roselló (2013).

In our opinion, future research could include a longitudinal study of several years to discern how the environmental disclosure and economic efficiency of Spanish ports authorities has evolved.

In this respect, in further study it would be pertinent to conduct an environmental performance and Eco-efficiency analysis (Burnett & Hansen, 2008; Haralambides & Gujar, 2012), applying a DEA model constructed from the environmental information reported by the PAs.

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