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Sustainability and the Spanish port system. Analysis of the relationship between economic and environmental indicators

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ABSTRACT

Research into the methodological development of alternative systems of sustainability measures is recent. In understanding sustainable development in a multi-dimensional sense, one of the most significant advances was the construction of Synthetic Indexes, applicable to different spatial spheres or to organisations, businesses, institutions, etc.

The Spanish port system of general interest comprises 46 ports integrated in 28 Port Authorities, which in 2014 moved 482,000,000 t of goods and more than 28 million passengers. This gives an idea of its importance for the Spanish economy.

Using a derivation of the procedure used to calculate the Port Sustainability Synthetic Index, in this research the analysis of the relationship that exists between the findings obtained for the economic and environmental dimensions is used. This enables the existence of links between ports and economic and environmental indicators for a sample of 16 Port Authorities of Spain to be verified.

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1. Measuring port sustainability: a review of the case study and proposals

The concern for sustainable development in port systems arose in the 1990s, leading to a huge amount of academic literature ranging from conceptual work through to design of environmental management systems, good practices, etc. On the contrary, there are very few methodological contributions to try to measure port sustainability. Exceptions would include the case of calculating the ecological footprint of ports undertaken for the Port of Gijón (Carrera Gómez et al., 2006) and subsequently extended to ports on the northern coast of Spain (Coto Millán et al., 2010); the carbon footprint study for European maritime transport (Leonardi and Browne, 2010), in the specific case of Barcelona port (Villalba and Gemechu, 2011) and for New Zealand, in which the increase of diesel consumption and its impact on greenhouse gases was analysed (Fitzgerald et al., 2011). For Barcelona, there has also been investigation into a

management system for the risks of water contamination (Grifoll et al., 2011) in a similar way as for the ports of Bulgaria (Quynh et al., 2011).

A proposal to apply Environment Management Systems (EMS) in specific ports, as well as a system of port sustainability indicators was undertaken by Peris Mora et al. (2005) for the case of Valencia as part of the Ecoport project, using a multi-criteria methodology that could be extended to European ports. A similar criterion was employed for the ports of Taiwan (Lu et al., 2012), Vietnam and Cambodia (Le et al. 2014). And lastly, Puig et al. (2015) analysed the environmental priorities of 79 European ports in accordance with their characteristics, based on the ESPO reports (ESPO, 2013) and a preliminary selection of Environmental Performance Indicators (Puig et al., 2014).

These previous contributions are clearly identified with the classic vision that identifies sustainability and the environment. If the number of proposals is already limited, those that introduce elements and dimensions befitting the integral concept of sustainable development (Martín Palmero, 2004, 49) are even fewer. The inclusion and analysis of the economic aspect stemming from the sustainability reports for Spanish ports was undertaken by Crespo et al. (2010), Asgari et al. (2015), and they applied an Analytic Hierarchy Process (AHP) to the ports of Great Britain to conduct a ranking of these ports based on economic and environmental

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aspects. Lastly, *Shiau and Chuang (2013)*, using a Social Construction Of Technology (SCOT) procedure, managed to identify sustainable development indicators for the Port of Keelung, with regard to environmental, economic and social dimensions.

Consequently, applied research concerning port sustainability reveals the following characteristics:

- In general, these involve contributions in the design of systems of indicators for specific cases using a range of methodologies.
- In the main they opt for identification between sustainability and the environment, and there are a few cases that actually analyse other dimensions of sustainable development or which provide quantitative systems of comparison and hierarchy between ports.

This research addresses the methodological development for calculation of a Port Sustainability Synthetic Index and, through a variation to this, the relationship that exists between the findings obtained for the economic and environmental dimensions of sustainable development is analysed. This enables a contrast of the links between both dimensions for a sample of 16 Spanish ports and a focus on orientations or guidelines with a view to improving each indicator.

2. Methodology

The use of individual values of variables to compare different economic, environmental or social realities normally offers irrelevant findings because they only deal with isolated data. Synthetic Indexes (SI) are aggregate indexes of simple, grouped and weighted variables based on certain scientific criteria and, therefore, they measure multi-dimensional concepts. This interrelation enables a full analysis of the reality and, consequently, the taking of decisions with regard to both the individual aspect and, above all, the integral aspect.

The SIs are for the purpose of studying organisations, productive processes, branches, companies, institutions, production and/or distribution units, etc. They adopt a pyramid structure, whereby the variables they comprise are in turn integrated into subindicators, indicators and, if applicable, dimensions. As well as being used to propitiate the comparability between different agents (such as those specified previously), they enable the formulation of efficiency and efficacy analysis, appropriate use of resources, as well as reputational aspects and, in general, all those that are defined by the appropriately selected variables.

The process of obtaining an SI requires several stages:

- Generation of an initial database, comprising the set of variables likely to form part of the subset or definitive database. Given the features of the SI, the variables considered must present quantitative and relative values (that allow a comparison), and therefore those that present categoric and/or quantitative values are not accepted.
- Identification and selection of the significant variables that will make up the final database. The information concerning the following aspects will be taken into consideration:

- The dimension where the variable fits.
- The indicator to which it belongs.
- Subindicator within which it is included.
- Specific data of the variable: definition and description of the measurement unit.
- Source of the information to calculate the values of the variable.
- Calculation method: formula for calculating the value of the variable.

- The values of the dimensions, if applicable, and/or of the SI is generally obtained by processing the data of the variables finally selected and with the following guidelines:

- The outliers of the variables are corrected, if necessary.
- The resulting values are typified.

- They are grouped by indicators and converted into standard normal percentiles with values of between 0 and 100
- The value of the Synthetic Index is calculated by weighting the average of the percentiles obtained for each one of the dimensions or components of the index.

This methodology allows different variants with their particularities and intermediate analysis system in accordance with the purposes of the research, or the specific characteristics of the type of institution, economic enterprise or company to which the analysis is to be applied.¹

In particular, the methodological procedure undertaken in this case comprises two completely different stages, as described below.

2.1. Origin of data

The Sustainability Reports of Spanish ports, constructed in accordance with the methodology implemented by *Puertos del Estado*, contain extremely valuable information on the performance of the 28 Port Authorities (PA) in this issue. On the basis of this and for 2012, a total of 60 variables were selected within the four dimensions of sustainable development (economic, institutional, environmental and social), which would comply with the comparability conditions required by the methodology adopted.²

The consistency and quality tests undertaken for the database corresponding to all of the PAs revealed 76.6% of valid variables. The different simulations conditioned the selection of a sample of 16 Port Authorities comprising 23 ports with data with the minimum standards of quality.³

Bearing in mind that the purpose of this research focuses on the economic and environmental dimensions of sustainable development, [Appendix A](#) shows the description and classification of variables and the groupings made for each of the dimensions dealt with.

2.2. Calculation of the value of components

Based on the selection of 33 variables, these were grouped into 13 subindicators, which in turn were concentrated in 5 indicators. Lastly, the indicators thus grouped were distributed into the two dimensions of the sustainable development to be analysed: economic and environmental. From then on, the process was carried out in accordance with the following specific guidelines:

- The first stage of calculations is carried out based on the different values observed and obtained for each of the 33 variables for the 16 Port Authorities considered.
- Secondly, the Z-scores are calculated, in other words the typified values of the variable, so that these are comparable.
- Then the values of the percentiles 97.5 and 2.5 are calculated to avoid extreme values distorting the results.
- The next and final stage of this initial process involves:

¹ *González Laxe and Martín Palmero (2004)* and *González Laxe, Martín Palmero and Fernández Francos (2004)* had already used a similar methodologic development to measure synthetic indexes of sustainability for the EU and the Spanish regions. These authors also used this method to analyse the convergence when it comes to sustainability for these regions regarding sustainable development for the period 1992–2002 (*González Laxe, Martín Palmero and Fernández Francos, 2010*). Finally, *González Laxe, Martín Palmero and Fernández Francos (2005)* developed an analysis about environmental and social indicators for Spanish regions also using this methodology.

² The design of the variable selection methodology for calculation of a Sustainability Synthetic Index of the Spanish Port System and the application of this was developed through a Research Agreement between the organisation *Puertos del Estado* and the University Institute of Maritime Studies of the UDC in 2013 and 2014.

³ More specifically, the definitive sample comprises 471 variable values over a total of 528 possible ones for the 16 Port Authorities, which reveals a level of 89.2% scope for the economic and environmental dimensions of sustainability.

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