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Assessment of port sustainability through synthetic indexes. Application to the Spanish case

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ABSTRACT

In general, Synthetic Indexes of sustainability have been applied to specific countries and regions. With some variations, the ones considered simple, such as the case of the Ecological Footprint (EF), have been applied to port areas. The same has not happened with those of a multidimensional nature (Global Synthetics) that still have a minimal and partial presence in the analysis of port sustainability.
Understanding that this type of index represents an interesting and novel avenue of research applied to port systems, this contribution analyses and ranks a sample of 16 Spanish Port Authorities that group 23 ports of general interest using a Global Synthetic Index of Sustainability (developed using the four dimensions of sustainable development: economic, institutional, environmental and social).

1. Introduction and objectives

Synthetic Indexes are traditionally used in economics to obtain aggregate information from a set of variables that are grouped into different levels of hierarchy. Sustainable development is a complex and multidimensional issue, so its evaluation requires the specific development of this kind of index, obtained through aggregations of individual variables (Bluszcz, 2016). In issues of sustainability, the most important applications in this area have been carried out in two categories: simple and global. The most important ones and the main contributions for each of them can be summarised as outlined in Table 1.

These indices were initially applied to countries, and then to areas or regions. Nevertheless, as regards simple synthetics (EF), very specific experiments for their use in port areas have already been conducted (Carrera Gómez et al. 2006; Coto Millán et al. 2010). However, to date no Global Synthetic Indexes have been proposed to measure port sustainability, although there have been references to certain partial aspects as in the case of economic and environmental dimensions (González Laxe et al. 2016).

Indeed, this path has been recently opened by Sislian, Jaegler and Carou (2016) who, following a complete and thorough review of the literature on port sustainability, recommend addressing it globally and from a three-dimensional perspective: economic, social and environmental. For these authors, this represents the new challenge in future research in this area.

Elsewhere, those three dimensions of sustainable development have been considered as basic, in the sense of providing them with a comprehensive approach to define sustainability from a multidimensional perspective. However, the latest recommendations on the subject advocate the inclusion of a fourth aspect: the institutional dimension, understood as the definition of transparent and independent forms of governance with objective criteria, so that the institutions themselves formulate policies to ensure the development of the other three dimensions. This dimension is therefore conceived as the one that propitiates the development and equilibrium of the others (Fernández Francos, Martín Palmero and Serrano Hidalgo, 2013).

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Table 1
Main synthetic indexes of sustainability.
Source: own elaboration, based on the classification of synthetic indicators proposed in Martín Palmero (2004).

		References	Characteristics
Simple	Ecological footprint (EF)	Wackernagel and Rees (1996)	It measures the area necessary to produce resources and assimilate the waste of a given population
Global	Environmental performance index (EPI)	World Economic Forum (2006-2016)	It initially develops a five-dimensional synthetic index for 146 countries (178 in 2014)
	Sustainable society index (SSI)	Van der Kerk and Manuel (2014)	This is based on 21 sustainability and quality of life indicators grouped into 5 categories for 150 countries.
	Synthetic indicator of sustainable development (SISD)	Bluszcz (2015)	It proposes a synthetic index for the 28 EU countries distributed in 3 dimensions (human, economic and environmental)

For its contribution within that line of proposed research, a Global Synthetic Index[1] (SI) is formulated and designed to measure Port Sustainability that is structured in a pyramid shape. The Synthetic Index comprises the four components or dimensions already defined (economic, institutional, environmental and social) divided into various indicators. These come from the calculation of a specific number of sub-indicators, each comprising a series of variables.[2] The variables considered essential to generate the Synthetic Index will be defined from the information and data contained in the Reports on Sustainability of the Spanish Port System.

2. Selection of variables and determination of the sample

Spanish Law 33/2010[3] on State Ports and the Merchant Marine establishes as one of the instruments for planning the port system of general interest is the need to introduce an annual plan in line with the Government's economic policy. This plan must be accompanied by a Sustainability Report developed in accordance with the methodology approved by *Puertos del Estado* (State Ports).[4]

The selection process of variables starts with the data contained in the Sustainability Reports of the 46 Spanish ports of general interest integrated into 28 Port Authorities (PAs), in this case for 2012 (González Laxe et al. 2016). Given that the variables to be considered should be measured in quantitative and relative terms, the maximum that can be selected (obtained either directly from the Reports or from derivative calculations) amounts to 56. Therefore, theoretically the total variables to be taken into consideration for the research would be 1568.

However, a thorough analysis of the information available in the Reports of each PA and its adaptation to the methodological specifications of State Ports on occasions reveals cases with shortfalls and a lack of information. Particularly, four ports do not reach 60% of their variables covered acceptably, while eight fail to reach 80%. Therefore, if the 28 Port Authorities are taken into consideration in the analysis, it is likely that the results of the research would prove inconsistent. To avoid this problem, through a continuous process of selection, an adequate sample comprising 16 Port Authorities has been considered as an appropriate sample (managing 23 ports) with an overall variables completion rate of 88.95%.[5] The distribution by dimensions is shown in Table 2.

Given that the Synthetic Index is constructed in a pyramidal shape, it is necessary to define how each of the 56 variables are grouped for each PA within the respective sub-indicators and these, in turn, into indicators, which make up each of the dimensions. This enables the integral and multidimensional perspective of sustainability to be collected. The groupings are shown in Table 3 and the breakdown of each of the components is included in the respective appendices.

3. Calculation methodology

Having determined the sample and selected the variables as noted in the previous section, the methodology based on which all the operational calculation of the Synthetic Index on Sustainability and its components consists of the following stages:

1. The first stage is carried out by forming the composite database with the different values observed and obtained from each of the 56 variables for each of the 16 Spanish PAs that make up the sample.
2. Then the values of the percentiles 97.5 and 2.5 are obtained with which to replace the maximum and minimum values of each of the variable values. This enables any excessively dispersed values to be corrected. The subsequent performance of the respective normality tests will serve to determine whether it should be carried out with more adjusted percentiles.
3. In third place, regarding the resulting distribution, the *Z*-score is calculated for each variable, in other words the typified values, so that these are comparable. The calculation can be obtained in two different ways:

$$Zs_i = \frac{Xi - \overline{X}}{\sigma x},$$

if the sense of sustainability is direct,[6] or

$$Zs_i = \frac{\overline{X} - Xi}{\sigma x},$$

if it is the other way round. In both cases:

Zs_i = Value of the typified variable.

$\overline{X}$ = Distribution average.

Xi = Value reached by the variable.

σx = Typical deviation of distribution.

4. Once every calculation of the 56 variables considered for the 16 PAs has been generated, it is necessary to continue with the subsequent process of identifying indicators, whose values are obtained by

[1] González Laxe and Martín Palmero (2004) developed a similar methodology to study and classify EU countries in accordance with a Synthetic Index on Sustainability, and González Laxe, Martín Palmero and Fernández Francos (2004), for the Spanish regions.

[2] The design of the variable selection methodology for calculation of a Synthetic Index of Sustainability of the Spanish Port System and the corresponding application were 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] Consolidated text approved through Royal Legislative Decree 2/2011.

[4] The methodology considers 111 indicators or obligatory variables of a descriptive, categorical or quantitative nature. A full development of the same can be consulted at Barcelona Port (2012).

[5] To achieve a percentage of 93.75% it would be necessary to restrict the sample to 6 ports, which would extremely limit the analysis. The 8 port authorities excluded from the final sample through insufficient information in their Reports are: A Coruña, Alicante, Almería, Balearic Islands, Bay of Cádiz, Ceuta, Ferrol, Marín, Pasajes, Tenerife, Seville and Tarragona

[6] The direct sense of sustainable development is understood when a higher value of the variable means a higher level of sustainability. When a lower value of the variable is indicative of greater sustainability, an indirect sense shall be understood.