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Low-cost port competitiveness index: Implementation in the Spanish port system ☆

José I. Castillo-Manzano [a], Mercedes Castro-Nuño [a], Fernando González Laxe [b,*], Lourdes López-Valpuesta [a], M. Teresa Arévalo-Quijada [a]

[a] University of Seville, Spain
[b] University of A Coruña, Spain

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ABSTRACT

Spanish Port Authorities currently face a wide range of complexities in their decision-making processes, as they have to satisfy several port management objectives that may conflict with one another. This paper examines these circumstances by using decision theory methodology with multiple objectives, which, through the Promethee method, makes the design of an index possible. This index combines different decision factors that shape the competitiveness of a port to rank the Spanish Port Authorities. This ranking serves as an alternative to the traditional ranking system by easily providing more information about port traffic.

The Promethee method was chosen because it is reliable, the outcomes are easy for decision makers to understand and the parameters can be economically interpreted. To account for any subjectivity in the measures for different criteria, we developed three survey campaigns aimed at the following groups: members of the port community, Port Authority managers and academic researchers.

1. Introduction

Since the 1990s, Spanish Port Authorities have faced increased competition due to changes affecting the sector on an international scale. These changes include the marked specialisation of traffic, the selectivity of routes, the development of port hierarchies, the containerisation process and the concentration of companies and businesses [1,2]. In addition, several external factors have been identified, such as the introduction of consecutive legal reforms [3,4].[1] As a consequence of these reforms, the Spanish port system is now run under a new port management model that is based on functional independence and financial autonomy. In practice, this involves moving away from the service model towards the tool model.

In order to rapidly adapt to this changing environment, especially in Spain where there are 28[2] Port Authorities competing in shared hinterlands, Spanish ports are obliged to devise port management strategies that give greater emphasis to providing competitive services.

Using multi-criteria decision theory, this research combines those aspects that have an impact on port competitiveness in a low-cost multi-dimensional index, which can be repeated on a

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* Corresponding author at: Instituto Universitario de Estudios Marítimos, Universidad de A Coruña, Campus Elviña, 15071 A Coruña, Spain. Tel.: +34 981 167000; fax: +34 981 167125.

E-mail addresses: jignacio@us.es (J.I. Castillo-Manzano), mercas@us.es (M. Castro-Nuño), laxe@udc.es (F.G. Laxe), lolopez@us.es (L. López-Valpuesta), arevalo@us.es (M. Teresa Arévalo-Quijada).

[1] Since the early 1990s there have been three legislative reforms of the Spanish port system, both in management and organisation. These reforms aimed at achieving greater autonomy, regional decentralisation, and promotion of the private sector. The two reforms in 1990s were Law 27/1992 of the Spanish State Ports and of the Merchant Navy, and its modification in Law 62/1997. Given a more competitive international context and a Spanish port system that had little dynamism with traffic growth rates nearing 2%, both laws tried to make ports more flexible. The first law converted ports in Port Authorities with legal status, own resources, and independence of the State, and also with a high level of autonomy in management, although coordinated by a state organism, the Spanish Port State Agency. The second law, Law 62/1997, fostered port decentralisation, allowing regional governments to appoint Presidents of Port Authorities, as well as some of their board members. It also intended to give more autonomy to Port Authorities and to favour inter-port competition by allowing them to fix their port tariffs, provided that port self-financing could be guaranteed. This kind of inter-port competition never came into effect and the tariff liberalization was abolished by Law 48/2003, on the Economic Regime and Services of Spanish State Ports. Law 48/2003 focuses on intra-port competition, by liberalising private sector access to port services; whereas the Port Authority acts as supplier and manager of port land and infrastructures, even allowing the private sector to become a stakeholder.

[2] In the period under consideration in this paper (1992–2003), they were only 27 Port Authorities. Subsequently, in October 2005, the Port Authority of Almeria-Motril became two Port Authorities.

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yearly basis for all Spanish ports. The profound changes that have taken place since the 1990s, especially the three legal reforms previously mentioned, justify a careful analysis of port competition from 1992 to 2003 (i.e., the years between the introduction of the first 27/1992 law and the latest 48/2003 law). This index also allows for additional port classification and comparison with the traditional ranking used for port statistics, based on the volume of traffic at each port.

2. Methodology

Given that there is no consensus about the ideal methodology for evaluating the competitiveness of port infrastructures, the wealth of literature on the subject provides rationale for the various possibilities (reviewed in depth by Teng et al. [5]). Methodologies can be grouped into two categories: firstly, quantitative methods that include data envelopment analysis (DEA) [6,7], productivity analysis [8,9], and regression techniques [10]; and secondly, a set of procedures, which under the multi-criteria decision-making method (MCDM), allow us to consider qualitative and quantitative indicators.

The MCDM method has many applications in economic analysis. When compared with conventional optimisation methods that provide a single solution (such as cost–profit analysis), MCDM permits a combination of different perspectives on conflicting issues to reach a balanced solution or consensus.[3] Additionally, the MCDM overcomes the main limitation of cost–profit analysis, which is the necessary translation of different factors of the problem into monetary units for assessing profitability. Therefore, MCDM is appropriate for contexts where decision making is based on a variety of viewpoints that are not always quantifiable. Given the multiplicity and variety of factors that influence strategies of port competitiveness, it was essential to use MCDM to achieve our research objective [13–16].

The development of MCDM in the field of transport management is extensive but relatively recent. Because of the finite nature presented by a set of alternatives, we use in this paper a discrete method. Thus, we found applications for evaluating expansion plans for air traffic infrastructures [17], city transport [18], as well as for the analysis of high-speed rail transport management [19].

The usefulness of MCDM has also been shown in the hierarchical organisation of port infrastructures [20–23] and in the analysis of port competitiveness, using the following multi-criteria procedures: grey relational analysis (GRA) [5], fuzzy multi-criteria grade classification model (FMGC) [13,16,24], Promethee-GAIA [15,25], and particularly, the multi-criteria procedure of the analytic hierarchy process (AHP). The AHPs were the most frequently used in recent studies [14,26,27].

The AHP method can be considered as a complete aggregation method of the additive type. The problem with such aggregation is that compensation between good scores on some criteria and bad scores on some other criteria can compensate each other, and some information can be lost by such aggregation [28].

To solve this problem, we used the Promethee analysis [15], chosen from the various multi-criteria techniques [29]. The Promethee analysis provides an overall ranking of alternatives (similar to AHP) but it also partially organises rankings and allows for the detection of possible incompatibilities (two or more alternatives where the difference cannot be determined) while allowing for additional assessment if needs arise.

[3] Extensive comparison of both analysis methods may be found in Roy [11] and Fuguitt and Wilcox [12], among others.

According to Brans and Vincke [29], the formulation of a multi-criteria problem using the Promethee method responds to the following model: $Opt\{f_1(a), f_2(a), \ldots, f_k(a), a \in A\}$ where A is a finite set of alternatives, and f_j, $j = 1, \ldots, k$ are the criteria to be taken into consideration. From this, we obtained a *decision matrix* or *evaluation table,* which includes evaluations of the alternatives of every single criterion.

The decision-making process begins once we have constructed the decision matrix, assigned importance weights w_j to the ratios and generalised the criteria (f_j, P_j), $j = 1, \ldots, k$. This procedure calculates the so-called *aggregated preference indexes* (defined as $\pi(a,b) = \sum_{j=1}^{k} w_j P_j(a,b)$, to show how alternative a is outranking b over all the criteria. It also calculates the *outranking flows* (*positive* $\phi^{+}(a) = 1/(n-1)\Sigma_{b\in A}\pi(a,b)$ and *negative* $\phi^{-}(a) = 1/(n-1)\sum_{b\in A}\pi(b,a)$) to express how much an alternative a is dominating (power of dominance) the other ones, and how much is dominated (weakness) by the other ones. The net flows $\phi(a) = \phi^{+}(a) - \phi^{-}(a)$ are based on the balance of the two preference flows.

Additionally, the GAIA plane is obtained as a result of the Promethee method. This result offers a clear graphic description of the decision problem in the k-dimensional space on a plane, where points represent the alternatives and vectors represent the criteria included on the *decision axis* (π). This analysis allows us to distinguish which alternatives are suitable for a specific criterion, and which criteria are conflicting [30,31].

3. Choice of the decision criteria

Using related studies as a point of reference [5,16], we used a definition of competitiveness that is based on the capacity of a port to create added value, generate a nucleus of business, and produce productive or industrial activity in the surrounding area. Thus, the most competitive port will be able to develop and apply a differentiated strategy, attracting more customers and traffic than its competitors. The complexity of this concept means that various aspects must be taken into account when identifying the decision factors for port competitiveness.

Each of the decision criteria used represented one of the aspects of competitiveness. When making these choices, we used the study criteria from Lirn et al. [26], Song and Yeo [14] and Guy and Urli [15] as our model. In addition, to avoid subjectivity when assigning importance to certain criteria, extensive surveys were carried out. During the surveys it was necessary to simplify the criteria definitions and to reduce the number of criteria in order to increase the number of responses.

Since our goal was to build a low-cost synthetic index of competitiveness, it was necessary to base the criteria on direct, quick and low-cost statistical sources. Thus, we used either annual port reports or information published by the Spanish Statistical Institute (INE). Table 1 shows the seven decision criteria.

4. Assignment of weights to decision criteria

Multi-criteria problems all have certain, yet unavoidable, variability when decisions about the weight of each criterion are being made. Since the relative importance of the criteria may not be the same when ordered by the Promethee MCDM, it is necessary to establish the importance of each criterion by giving them weightings or adjustments. When weights were assigned, it was essential that the authors' perspectives about the port sector did not influence any decisions.

Previous articles [15,32,33] proposed that more than one scenario of analysis should be introduced to control for the restricting factor mentioned above. Therefore, our study initially

Table 1
Decision criteria.

Criteria	Definition[a]
Economic profitability: a standard formulation, measuring the result of exploitation on the business asset	$R_1 = \mathrm{NB}_{it}/\mathrm{TA}_{it}$ NB_{it}: Net benefit of port i in year t = exploitation incomes–exploitation expenses. TA_{it}: Total assets according to the situation balance of port i in year t.
Dynamism of port activity: an annual growth rate of total port traffic	$R_2 = (\mathrm{TRAFF}_{it} - \mathrm{TRAFF}_{it-1})/\mathrm{TRAFF}_{it-1}$ TRAFF_{it}: Thousands of tons of total traffic moved in port i in year t. TRAFF_{it-1}: Thousands of tons of total traffic moved in port i in the year t–1.
Specialisation in containers: it can become a proxy variable to show the degree of involvement of each port in the gradual process of contenedorisation of international shippin.	$R_3 = \mathrm{TRAFFCONT}_{it}/\mathrm{TRAFF}_{it}$ $\mathrm{TRAFFCONT}_{it}$: Thousands of containerised tons moved in port i in year t. TRAFF_{it}: Thousands of tons of total traffic moved in port i in year t.
Investment in fixed capital: measured through the growth rate of fixed capital of each Port Authority	$R_4 = (\mathrm{FA}_{it} - \mathrm{FA}_{it-1})/\mathrm{FA}_{it-1}$ FA_{it}: Total fixed assets according to the balance of situation in port i in year t. FA_{it-1}: Total fixed assets according to the balance of situation in port i in year t–1.
Importance of the Strictly port business: measured by the revenues from tariffs to the passage and cargo[b], against the total port revenues, including concessions[c]	$R_5 = \mathrm{REVPC}_{it}/\mathrm{TOTREV}_{it}$ REVPC_{it}: Revenues of port i in year t, coming from tariffs T-2 (passengers) and T-3 (cargo). TOTREV_{it}: Total revenues of port i in year t (port tariffs+canons and concessions).
Productivity of labour factor: the numerator is a representative magnitude for the "port throughput" (revenues coming from port tariffs), and the denominator is only referred to the workers of the different Port Authorities, so the workers of private terminals were excluded[d]	$R_6 = \mathrm{REVTAR}_{it}/\mathrm{LC}_{it}$ REVTAR_{it}: Revenues of port i in year t, coming from tariffs T-0 (signalling), T-1 (vessels), T-2 (passengers), T-3 (cargo), T-4 (fishery), T-5 (sport and pleasure boats), T-6 (portal cranes), T-7 (storage), T-8 (supplies) and T-9 (other services). $\mathrm{LC}_{\mathrm{it}}$: Labour costs of port i in year t.
Economic dynamism: (measured by the growth rate of GDP at constant prices[e]) of the port hinterland. It starts from the premise that a competitive port affects positively to the evolution of the economic activity of its hinterland or zone of geographical influence, and vice versa; that is, a dynamic hinterland must impact on port competitiveness	$R_7 = \frac{GDP_{it} - GDP_{it-1}}{GDP_{it-1}}\ \rho + \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} \leftrightarrows (1-\rho)$ GDP_{it}: GDP of the province of port i in year t. GDP_{it-1}: GDP of the province of port i in year t–1. GDP_t: GDP of Spain in year t. GDP_{t-1}: GDP of Spain in year t–1. ρ: Percentage of port traffics from/to the province of the port[f].

[a] The data for calculating the ratios was taken from: National Institute of Statistics (www.ine.es); Port Authorities annuals (1990–2004) and statistics and management reports from Spanish Port State Agency. (www.puertos.es) as well as from annual reports from the Central Bank of Spain (www.bde.es).

[b] Since 2003 was the last year analysed, we did not take into account the new classification of Port Taxes and Tariffs that came into effect in 2004 with Law 48/2003. The same is valid for R_6.

[c] Thus, we aim to exclude analyses not strictly related to ports, such as those supplied by historic ports that have reformed historic facilities situated within the city, lucrative businesses (malls, social clubs, offices, car parks).

[d] Gathering information from employees of private terminals for all Spanish ports would be very expensive, and would make our objective (developing a low-cost synthetic index), impossible.

[e] The provincial GDP data published by the National Institute of Statistics are valued at current prices. For this reason they have been deflated through the GDP deflator published by the Central Bank of Spain.

[f] ρ has been calculated as the arithmetic average of the hinterlands of Spanish ports by García [35]. This study only calculated the hinterlands of peninsular ports. For island ports and north-African ports, as they represent captive hinterlands, we have assumed $\rho = 0.95$, that is, 95% of traffic generated in the province will use this port. Although this may seem a restrictive hypothesis, geographic reality confirms this assumption, since it is impossible for island and north-African provinces to use another port (since there is no business frontier with Morocco).

had developed three scenario assessments formed by adjudicators from different spheres, which included: the academic sector (researchers in transport management), Port Authorities and the Spanish Port State Agency (experts from the public sector) as well as the port community. The three groups of adjudicators were consulted throughout our survey campaigns. The main features of these campaigns are outlined below.

Scenario I: *Survey campaign to the academic sector.* The survey was sent by mail to 26 faculty members and researchers at different Spanish universities; 18 of these responded. The expertise of this panel was in Transport Economics in general, and Maritime and Port Management in particular, with specialised publications on these matters.

Scenario II: *Survey campaign to Port Authorities and managers of the Spanish Port State Agency*. This survey was sent by mail to all Port Authorities with a letter from the Managing Director of the Spanish Port State Agency (SPSA) supporting this research. The campaign was successful, as all Spanish Port Authorities answered the survey (by mail, e-mail or fax), except for Aviles and Tarragona (i.e., 26 out of 28 Port Authorities). In addition, four top-level managers for the Spanish Port State Agency also responded to the survey. Thus, there were a total of 30 answers.

Scenario III: *Survey campaign to shipping associations and maritime operators.* The survey was sent to all national associations of port businesses, as well as different operators working at the ports of Bahía de Algeciras, A Coruña, Ferrol-San Cibrao, Huelva and Seville (in total, 25 associations and operators). Finally, 16 associations and companies of the port community (including consignors, shipping companies, customs agents, etc.) responded to the survey.

The rating technique [34] was used to aggregate the assessments by the various expert panels. This method was chosen because it simplified the survey design and the rules that were imposed on the experts. This was done to maximize the number of answers from non-academic adjudicators (managers of Ports Authorities and the Spanish Port State Agency, or port operators) who may not be familiar with more complex assessment techniques.

Briefly, the rating method is defined as follows: Let w_l be the associated weight to criterion l ($l = 1, \ldots, k$). For the sake of mathematical convenience, weights are usually normalised to 1, so that: $0 < w_l < 1$ and $\sum_{l-1}^{k} w_l = 1$. The criteria (the seven decision criteria, in this case) are presented to each expert and a value is established for each one. The values of classification range from 0.0 to 10.0 or 100.0, with the possibility that more than one

Table 2
Weights and average values assigned to decision criteria in the survey campaigns (64 responses).

Decision criteria	Academic sector		Port authorities and SPSA		Port community	
	Average values	Weights	Average values	Weights	Average values	Weights
Economic profitability	6.73529	0.14814	6.54839	0.14156	5.81250	0.12722
Dynamism of port activity	6.82352	0.14144	8.00000	*0.17247*	7.59375	*0.16903*
Specialisation in containers	6.70588	0.14106	5.69355	0.12209	6.12500	0.13563
Investment in fixed capital	6.17647	0.13308	6.82258	0.14557	6.06250	0.13005
Strictly port business	6.70588	0.14367	6.20968	0.13413	6.75000	0.14826
Productivity of labour factor	6.94117	*0.15124*	5.64516	0.11872	5.81250	0.12833
Economic dynamism of hinterland	6.79411	0.14137	7.64516	0.16546	7.50000	0.16146
Standard deviation	0.24414	0.00580	0.9102481	0.02035	0.76732	0.01699

Note: The highest weight assigned for each panel of experts is in italics.

Table 3
Weights and average values assigned to decision criteria in the survey campaigns (36 responses).

Decision criteria	Academic sector		Port authorities and SPSA		Port community	
	Average values	Weights	Average values	Weights	Average values	Weights
Economic profitability	7.41667	0.16537	6.91667	0.13648	5.66667	0.12595
dynamism of port activity	6.25000	0.12726	9.25000	*0.18588*	7.45833	*0.16827*
Specialisation in containers	6.08333	0.12784	6.12500	0.12104	6.00000	0.13477
Investment in fixed capital	6.33333	0.13423	8.04167	0.15937	6.16667	0.13252
Strictly port business	6.83333	0.14284	5.87500	0.11413	6.50000	0.14377
Productivity of labour factor	7.75000	*0.17016*	6.08333	0.11758	6.16667	0.13848
Economic dynamism of hinterland	6.58333	0.13231	8.16667	0.16553	7.25000	0.15624
Standard deviation	0.62546	0.01782	1.29636	0.02774	0.662749	0.014737

Note: The highest weight assigned for each panel of experts is in italics.

criterion has the same position. Weights are obtained from the initial ordering as follows:

$$w_{lj} = \frac{p_{lj}}{\sum_{l=1}^{k} p_{lj}} \quad \text{and} \quad w_l = \frac{\sum_{j=1}^{n} w_{lj}}{\left(\sum_{j=1}^{n}\sum_{l=1}^{k} w_{lj}\right)}$$

where w_{lj} is the weight for criterion 1 by expert j; p_{lj} the position of criterion 1 by expert j and w_l the aggregated weight of criterion 1 by all experts.

Table 2 shows the results of the rating method for the answers assigned to decision criteria from the three campaigns. The first notable result is the high average value that the three adjudicator groups gave to each criterion (from 5.66 to 8.00). This supports the choice of criteria where each one represents a competitiveness aspect according to the 64 adjudicators. On the other hand, according to the standard deviation for each category, the evaluations of the adjudicators in Scenarios I and III did not differ significantly from the average value of the weights (0.1428); this is logical since no criterion had a low evaluation (less than 5).

In order to achieve a higher level of discrimination between criteria, the adjudicating panels were homogenised and the number of adjudicators was reduced to 12 per panel.[4] The following criteria were used to select panellists.

Scenario I.H: Twelve researchers who had the best curriculum vitae in Transport Economy and published on Maritime and Port Management were chosen.

Scenario II.H: The top manager of the Spanish Port State Agency and the directors of the 11 most important ports in terms of traffic volume.

Scenario III.H: The six national associations that responded to the survey, together with the six businesses that had the greatest invoice volumes of 2006 (the year that the surveys were conducted).

Table 3 shows the new results. The evaluation values given to the criteria increased, namely 90% of the criteria have an average value over 6.00. In addition, the standard deviation of two of the categories of adjudicators in Scenarios I.H and II.H increased, while the standard deviation of Scenario III.H decreased. This may be explained by the high level of heterogeneity of the port community group, as it was comprised of many types of operators (shipping companies, transit companies, customs agents or consignees). These operators may have very different ideas regarding port competitiveness.

Both Tables 2 and 3 illustrate that there are two different visions of the understanding of port competitiveness. Firstly, there is the economist vision of the academy (Scenarios I and I.H) that gives greater importance to managerial aspects such as the productivity of labour and economic profitability. Secondly, there exists the engineering and geographic vision of the professionals in Scenarios II, II.H, III and III.H. It is clear that both public sector experts and the port community consider the most important factor to be the growth rate of traffic, followed by hinterland dynamism, i.e., the port relationship with its geographical area.

[4] Although the homogenisation means to reduce the number of judges from 64 to 36, the new results are still significant due to the chosen selection criteria to reduce the number of judges (the most important ports, the best academic curricula…). We also consider that the reduced number of judges of the homogenised scenarios is more than enough, as similar researchers have proved with even a slightly less number of judges [36,37].

5. Results

Once the different scenarios were considered, the studies based on the Promethee methodology do not usually discriminate between them. Furthermore, the variety of scenarios is presented as an indicator of the wealth of the research [15,32,33]. As our objective was to develop a complementary port ranking to replace the traditional ranking for port traffic, we chose to use only one scenario.

To select a specific scenario from the six outlined, we propose two procedures based on the weight sensitivity analysis. For each weight w_j, $j = 1, \ldots, k$, the Promethee method provides a sensitivity interval $[a_j, b_j]$, $j = 1, \ldots, k$, which indicates the values that the weights w_j may oscillate between without changing the solution. The solution will be more robust in terms of changes in weights when they are more centred on their sensitivity intervals. The two formulations are outlined below:

Limitation 1*:*

$$\operatorname*{Min}_{i=1,\ldots,6} \frac{\sum_{t=1992}^{2003}\sum_{j=1}^{7}\left| w_{ij}^{t} - \frac{a_{ij}^{t}+b_{ij}^{t}/2}{b_{ij}^{t}-a_{ij}^{t}} \right|}{12}$$

The optimum scenario $(i = 1, \ldots, 6)$ will be the one that minimises the average for the 12-year period under consideration $(t = 1992, \ldots, 2003)$ and the total distance of weight for each criterion $(j = 1, \ldots, 7)$ to the centre of its interval. This distance has been homogenized by dividing by the amplitude of each interval.

Limitation 2*:*

$$\operatorname*{Min}_{i=1,\ldots,6} \frac{\sum_{t=1992}^{2003} \operatorname*{Max}_{1\leqslant j\leqslant 7}\left\{ \left| \frac{w_{ij}^{t}-a_{ij}^{t}+b_{ij}^{t}/2}{b_{ij}^{t}-a_{ij}^{t}} \right| \right\}}{12}$$

According to this criterion, the scenario in which the average maximum distances of each weight to the centre of its interval will be the minimum, during the time period under consideration.

Table 4 shows the results of the formulations for the six proposed scenarios for each year of the period studied (1992–2003). The average of each scenario for both procedures is given in the last row. Scenario I.H (the academic survey with 12 adjudicators) is the most robust evaluation, as it has the lowest average value for the two procedures.

Table 5 shows the rankings resulting from the six scenarios, together with the traditional ranking for 2003, which was the last year under consideration. Additionally, in Fig. 1 the GAIA diagram can be seen as the Scenario I.H, the most robust evaluation, in 2003. Regarding the position of the alternatives, the diagram depicts graphically the results from Table 5 for this scenario. The three ports were ranked as follows: Bahía de Algeciras (ALGE), Valencia (VAL) and Barcelona (BAR), for being the ones furthermost in the direction of the *decision axis* (π). On the other hand, a similar pattern may be appreciated between certain groups of ports, with regard to the same criteria, because their representative triangles are very close to each other in the diagram. This is the case for the ports in Tenerife (TEN), Bilbao (BIL), Las Palmas (LAS) and Vigo (VIG).

6. Conclusions

New models for port management, similar to the Spanish system, which are based on port autonomy, have a growing list of objectives, such as logistical functions and new demands such as self-funding. To define and account for these new objectives, it is advisable to work with a great wealth of statistical sources and ranking systems, which provide more information than the volume of total traffic alone. This paper offers a straightforward methodology for elaborating on a complementary alternative to the traditional ranking system; this new method can easily be adapted to any port system.

Some of the advantages of this methodology are: transparency, (primary data is used from the most common statistical sources such as the National Institute of Statistics or the Spanish Port State Agency); the combination of different aspects of competitiveness among Spanish ports into a single value, with all the aspects being as relevant as if they were given high grades by 64 adjudicators; overcoming subjectivity problems when giving weight to different criteria; and finally, based on robust criteria, it is provided a straightforward method for selecting scenarios is provided.

The process of developing the new ranking system has brought other observations to light. There are different visions regarding port competitiveness of the academy in comparison with sector professionals. Port professionals, including both the public sector (Port Authorities and Spanish Port State Agency) and the private sector (port community), would like to focus more on traffic or on

Table 4
Comparison of the robustness of the six scenarios.

Year	64 Adjudicators						36 Adjudicators					
	Scenario I: academic sector		Scenario II: port authorities and SPSA		Scenario III: port community		Scenario I.H: academic sector		Scenario II.H: port authorities and SPSA		Scenario III.H: port community	
	Index of the robustness of the solution		Index of the robustness of the solution		Index of the robustness of the solution		Index of the robustness of the solution		Index of the robustness of the solution		Index of the robustness of the solution	
	Sum	Min max	Sum	Min max	Sum	Min max	Sum	Min max	Sum	Min max	Sum	Min max
1992	1.5911	0.3432	3.3887	0.5	3.3887	0.5	2.0236	0.4526	2.0287	0.4167	1.9556	0.4574
1993	1.5137	0.4259	3.1738	0.4861	2.3960	0.4708	1.0206	0.3461	2.6694	0.4697	0.7202	0.2643
1994	0.7750	0.1875	2.5846	0.4784	1.993	0.4038	1.0975	0.3403	0.9907	0.3165	1.7161	0.4085
1995	0.8541	0.2842	0.7211	0.2667	2.7441	0.5	1.1158	0.3293	2.0481	0.4687	3.0293	0.5
1996	2.4260	0.4634	1.0990	0.2872	1.4471	0.3270	0.8505	0.2528	1.0721	0.3667	1.9229	0.4111
1997	0.9945	0.3070	2.5021	0.4652	1.8106	0.4273	1.1562	0.2273	2.2830	0.4697	2.0299	0.4783
1998	1.4744	0.3025	3.1940	0.5	1.3555	0.3974	0.8034	0.2250	1.0401	0.2885	1.1171	0.3396
1999	1.1957	0.2674	0.9926	0.2327	0.9223	0.2443	1.3250	0.2980	1.1341	0.3065	0.8978	0.2879
2000	0.7109	0.2027	1.7767	0.3691	0.9227	0.2555	1.1693	0.2743	0.9614	0.3230	1.3845	0.3333
2001	2.0369	0.3805	0.9138	0.2719	1.7731	0.3975	1.8924	0.4130	1.9270	0.4217	1.1350	0.2919
2002	1.4612	0.4105	2.9494	0.4907	2.0143	0.3981	1.3454	0.3832	1.1694	0.3320	1.5083	0.4348
2003	1.7336	0.4067	2.7549	0.4881	2.2415	0.4622	2.9024	0.4157	2.3917	0.4193	1.7899	0.4496
Average	1.3972	0.3318	2.1708	0.4030	1.9174	0.3986	1.3918	0.3298	1.6429	0.3832	1.6005	0.3880

Table 5
Comparison of rankings in 2003.

Order	64 Adjudicators			36 Adjudicators			Traditional classification according to port traffic
	Scenario I: academic sector	Scenario II: port authorities and SPSA	Scenario III: port community	Scenario I.H: academic sector	Scenario II.H: port authorities and SPSA	Scenario III.H: port community	
1	Bahía de Algeciras	Bahía de Algeciras	Bahía de Algeciras	Bahía de Algeciras	Bahía de Algeciras	Bahía de Algeciras	Bahía de Algeciras
2	Valencia	Barcelona	Valencia	Valencia	Barcelona	Valencia	Barcelona
3	Barcelona	Valencia	Barcelona	Barcelona	Valencia	Barcelona	Valencia
4	Cartagena	Cartagena	Cartagena	Cartagena	Cartagena	Cartagena	Tarragona
5	Tenerife	Las Palmas	Tenerife	Almería-Motril	Las Palmas	Tenerife	Bilbao
6	Las Palmas	Almería-Motril	Las Palmas	Tenerife	Almería-Motril	Las Palmas	Las Palmas
7	Almería-Motril	Tenerife	Almería-Motril	Las Palmas	Tenerife	Almería-Motril	Cartagena
8	Baleares	Bilbao	Bilbao	Baleares	Vigo	Bilbao	Gijón
9	Bilbao	Vigo	Vigo	Bilbao	Bilbao	Baleares	Huelva
10	Vigo	Baleares	Baleares	Vigo	Baleares	Vigo	Tenerife
11	Alicante	Alicante	Alicante	Alicante	Alicante	Alicante	A Coruña
12	Ferrol-San Cibrao	Ferrol-San Cibrao	Ferrol-San Cibrao	Ferrol-San Cibrao	Avilés	Ferrol-San Cibrao	Baleares
13	Avilés	Avilés	Avilés	Avilés	Ferrol-San Cibrao	Avilés	Castellón
14	Castellón	Huelva	Huelva	Castellón	Huelva	Huelva	Ferrol-San Cibrao
15	Huelva	Castellón	Castellón	Huelva	Castellón	Castellón	Almería-Motril
16	Bahía de Cádiz	Bahía de Cádiz	Bahía de Cádiz	Tarragona	Bahía de Cádiz	Bahía de Cádiz	Pasajes
17	Tarragona	Villagarcía	Villagarcía	Bahía de Cádiz	Villagarcía	Villagarcía	Santander
18	Villagarcía	Marín-Pontevedra	Tarragona	Ceuta	Marín-Pontevedra	Tarragona	Seville
19	Ceuta	Tarragona	Marín-Pontevedra	Villagarcía	Tarragona	Marín-Pontevedra	Avilés
20	Marín-Pontevedra	Ceuta	Ceuta	Marín-Pontevedra	Ceuta	Ceuta	Bahía de Cádiz
21	Gijón	Gijón	A Coruña	Gijón	Gijón	Gijón	Vigo
22	A Coruña	A coruña	Gijón	A Coruña	A Coruña	A Coruña	Alicante
23	Melilla	Pasajes	Pasajes	Melilla	Pasajes	Pasajes	Malaga
24	Santander	Melilla	Santander	Santander	Málaga	Santander	Ceuta
25	Pasajes	Málaga	Málaga	Pasajes	Melilla	Melilla	Marín-Pontevedra
26	Seville	Santander	Melilla	Seville	Santander	Málaga	Villagarcía
27	Málaga	Seville	Seville	Málaga	Seville	Seville	Melilla

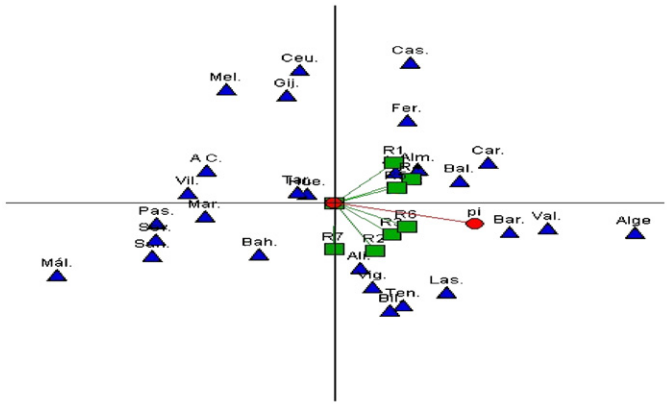

Fig. 1. GAIA diagram of Scenario I.H in 2003.

port relationships with surrounding areas. The academic sector, on the other hand, believes that port management is more important to competitiveness.

It is remarkable that all the scenarios in which the characteristics of the judges have been homogenised (I.H, II.H and III.H) have lower averages in both criteria to establish robustness than their corresponding scenarios without homogenising (see Table 4). This situation itself would justify any effort carried out to homogenise the characteristics of the judges employed to determine the weights.

Finally, the proposed rankings provide a different and more dynamic vision with greater information about Spanish ports, without neglecting its graphic representation through the GAIA diagram. In Table 5, the six new rankings agree with the traditional one for the three largest ports (Bahía de Algeciras, Barcelona and Valencia), which is a logical consequence of their positions as international reference points for container traffic in the Mediterranean. By definition, this obliges them to maintain a high level of competitiveness. It is worth noting that four of the alternative rankings, the ones from the academic sector and from the port community, place Valencia higher than Barcelona. Thus they foresee the relative positions that both cities have in the traditional ranking since 2007, when Valencia's traffic became greater than Barcelona's.

The alternative rankings and the traditional ranking differ considerably after the third place. The differences can be summarised in two port groups. The ports in the first group are placed higher in the alternative rankings than if traffic volume had been the only consideration (see for example Almería-Motril or Alicante). Ports in this group are striving to improve their competitive edge. Ports in the second group, positions 21–27, apart from Melilla, have better positions in the traditional ranking than in the competitiveness rankings. This demonstrates the difficulties these ports have in conserving their appeal within the framework of greater competition between ports caused by changes in the laws regulating their activity. Therefore, it is not surprising that over the last few years many of these ports (for example, Málaga, Seville or A Coruña) have made significant investments by completely transforming their facilities and even, on occasion, moving sites.

It might be worth highlighting that apart from the important differences in the weights within the six proposed scenarios/rankings, there are more similarities among them than the one obtained with the traditional ranking.

References

[1] Rodrigue JP. Globalization and the synchronization of the transport terminals. Journal of Transport Geography 1999;7:255–61.
[2] Bichou K, Gray R. A critical review of conventional terminology for classifying seaports. Transportation Research: A 2005;39:75–92.
[3] Suárez de Vivero JL, Rodríguez-Mateos JC. Spain and the Sea. The decline of an Ideology, crisis in the Maritime sector and the challenges of globalization. Marine Policy 2002;26(3):143–53.
[4] Castillo-Manzano JI, Lopez-Valpuesta L, Perez JJ. Economic analysis of the Spanish port sector reform during the 1990s. Transportation Research: A 2008;42(8):1056–63.
[5] Teng J, Huang W, Huang M. Multicriteria evaluation for port competitiveness of eight East Asian container ports. Journal of Marine Science and Technology 2004;12(4):256–64.
[6] Tongzon J. Efficiency measurement of selected Australian and other international ports using data envelopment analysis. Transportation Research: A 2001;35(2):107–22.
[7] Tongzon J, Heng W. Port privatization, efficiency and competitiveness. Some empirical evidence form container ports (terminals). Transportation Research: A 2005;39(5):405–24.
[8] Sachish A. Productivity functions as a managerial tool in Israeli ports. Maritime Policy and Management 1996;23(4):341–69.
[9] Robinson D. Measurement of port productivity and container terminal design. A Cargo system report. London: IIR Publications; 1999.
[10] Haezendonck E, Notteboom T. The competitive advantage of seaports. In: Huybrechts M, Meersman H, Van de Voorde E, Van Hooydonk E, Verbeke A, Winkelmans W, editors. Port competitiveness: an economic and legal analysis of the factors determining the competitiveness of Seaports. Antwerp: De Boeck Ltd.; 2002.
[11] Roy B. Methodologie multicritere d'aide a la decision. Paris: Ed. Economica; 1985.
[12] Fuguitt D, Wilcox SJ. Cost–benefit analysis for public sector decision makers. Westport: Ed. Quorum Books; 1999.
[13] Huang W, Teng J, Huang M, Kou M. Port competitiveness evaluation by fuzzy multicriteria grade classification model. Journal of Marine Science and Technology 2003;11(1):53–60.
[14] Song D, Yeo K. A comparative analysis of Chinese container ports using the analytical hierarchy process. Maritime Economics and Logistics 2004;6: 34–52.
[15] Guy E, Urli B. Port selection and multicriteria analysis: an application to the Montreal-New York alternative. Maritime Economics and Logistics 2006;8: 169–86.
[16] Yeo K, Song D. An application of the hierarchical fuzzy process to container port competition: policy and strategic implications. Transportation 2006;33: 409–22.
[17] Vreeker R, Nijkamp P, Terwelle C. A multicriteria decision support methodology for evaluating airport expansion plans. Transportation Research: D 2002; 7(1):27–47.
[18] Teng J, Tzeng G. Fuzzy multicriteria ranking of urban transportation investment alternatives. Transportation Planning and Technology 1996;20(1): 15–31.
[19] Janic M. Multicriteria evaluation of high-speed rail, transrapid maglev and air passenger transport in Europe. Transportation Planning and Technology 2003;26(6):491–512.
[20] Brooks MR. An alternative theoretical approach to the evaluation of liner shipping. Maritime Policy and Management 1985;12:145–55.
[21] Frankel EG. Hierarchical Logic in shipping policy and decision-making. Maritime Policy and Management 1992;19:211–21.
[22] Hokkanen J, Lahdelma R, Salminen P. A multiple criteria decision model for analyzing and choosing among different development patterns for the Helsinki cargo harbor. Socio-Economic Planning Sciences 1999;33(1): 1–23.
[23] Lirn T, Thanopoulou H, Beresford A. Transshipment port selection and decision-making behaviour: analysing the Taiwanese case. International Journal of Logistics Research and Applications 2003;6:229–44.
[24] Chou T, Liang G. Application of a fuzzy multicriteria decision-making model for shipping company performance evaluation. Maritime Policy and Management 2001;28(4):375–92.
[25] Macharis C. Hybrid modelling: system dynamics combined with multicriteria analysis. An application to intermodal transport. Bergen Noorwegen: System Dynamics Conference; 2000.
[26] Lirn T, Thanopoulou H, Beynon M, Beresford A. An application of AHP on transhipment port selection: a global perspective. Maritime Economics and Logistics 2004;6:70–91.
[27] Ugboma CH, Ugboma O, Ogwude I. An analytic hierarchy process (AHP) approach to port selection decisions—Empirical evidence from Nigerian ports. Maritime Economics and Logistics 2006;8:251–66.
[28] Macharis C, Springael JD, De Brucker K, Verbeke A. PROMETHEE and AHP: the design of operational synergies in multicriteria analysis. Strengthening PROMETHEE with ideas of AHP. European Journal of Operation Research 2004;153:307–17.
[29] Brans JP, Vincke P. A preference ranking organisation method. Management Science 1985;31:647–56.
[30] Karkazis J. Facilities location in a competitive environment: a Promethee based multiple criteria analysis. European Journal of Operational Research 1989;42(3):294–304.
[31] Marchant T. Promethee and GAIA in a multi-decision maker environment. Ricerca Operativa (A quarterly Journal of Operations Research) 1996; XXVI(79):19–43.

[32] Wright G, Goodwin P. Future-focused thinking: combining scenario planning with decision analysis. Journal of Multi-Criteria Decision Analysis 1999;8: 311–21.
[33] Goodwin P, Wright G. Enhancing strategy evaluation in scenario planning: a role for decision analysis. Journal of Management Studies 2001;38:1–16.
[34] Tabucanon MT. Studies in production and engineering economics, in multiple criteria decision making in industry. Elsevier Science Publishers; 1988.
[35] García L. Competencia Interportuaria: delimitación y análisis del área de influencia de los puertos españoles. University of Oviedo; 2005.
[36] Teng JY, Huang WC, Huang MJ. Multicriteria evaluation port competitiveness of eight east Asian container ports. Journal of Marine Science and Technology 2004;12(4):256–64.
[37] Chou CC. A fuzzy MCDM method for solving marine transhipment container port selection problems. Applied Mathematics and Computation 2007;186:435–44.