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Case study

Measuring the efficiency of heritage institutions: A case study of a regional system of museums in Spain

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Abstract

Data Envelopment Analysis (DEA) is a widely applied tool in efficiency evaluation for public administration, yet has scarcely been put to use in the case of heritage institutions. The goal of the current paper is to evaluate the technical efficiency of a regional system of museums, the hypothesis being that these bodies represent one organization of productive resources (employment, equipment, art collections, and so on), aimed at providing various goods and services linked to their basic functions: conservation, exhibiting, research and dissemination of cultural heritage. Yet, given the diverse nature of this kind of institution, previous sorting and classification is required in order to obtain homogeneous clusters for the various elements. This research therefore merges multivariate statistical techniques to synthesise the initial information and DEA for efficiency evaluation. These findings may prove useful for management of these institutions, as well as for those responsible for public resource allocation policies in the area of cultural heritage. We apply this to a regional system of museums in Spain, which includes both rural and urban museums.

Keywords: Economics of heritage; Museums; Efficiency; Data Envelopment Analysis; Multivariate analysis; Spain

1. Research aims

Museums are perhaps the most representative of all manifestations of cultural heritage, as they perfectly sum up the desire to preserve the legacy handed down to us by our ancestors, as well as the wish to maintain and select those assets which reflect the creativity and identity of a society. However, museums are not just a lifeless ensemble of artefacts as are other kinds of cultural heritage such as historical buildings and archaeological diggings and so on. They represent a specific type of cultural creation, are managed in a particular style, and how the various exhibits housed in the museum's collection are displayed or how much of an impact their various activities have, may affect to a greater or lesser extent the institution's appeal and the number of visitors it attracts.

From the analytical viewpoint, museums also provide a fruitful area for case studies in the field of cultural economics for several reasons. Firstly, they are clearly bounded, and directly reflect consumers' preferences and predilections through visits to the museum, which is generally quantified, thus encouraging numerous studies into dimension and estimation. Secondly, interesting and varied analyses emerge from the study of museum ownership and management, which may differ tremendously, ranging from purely public ownership to private stakeholders and, increasingly, non-profit foundations. The differing legal status closely reflects how each country manages its public commodities, in particular cultural assets and facilities (in short, the Latin or continental approach and the Anglo-American style, respectively), the significant consequences of which merit analysis, both in terms of institutional management as well as the likely impact of museum activities.

Finally, museums form a symbolic part of cultural policies and economic development plans, as they are regarded as a source of wealth and a magnet for tourism and the resulting spending. Museums also play a role in urban restoration, and indeed may even be key to a city's change of image through

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investments in new urban facilities which are ex novo cultural attributes. This is the setting which has seen the proliferation of museums since the mid-1980s, and has seen the emergence of new museums in both rural and urban environments, offering either a complete range of exhibits or those dedicated to one theme, housed in new architectural creations or in pre-existing restored buildings, and so on. This has meant that we are currently witnessing what many authors see as the second museum boom in history, similar in form, yet smaller in scale to the creation of 19th Century museums.

Museum economics constitutes a well established and fertile sector within the field of economics of heritage [1–4], covering issues which range from research into scale and economic impact [5–7], to areas related to microeconomic aspects linked to management, cost structures and admission price policy [8,9], and finally works addressing financial assessment and demand curves for non-market goods [10–14]. One area arousing growing interest is efficiency analysis of these institutions, since museums are in fact public entities managing a series of resources aimed at producing various goods and services for society.

According to the International Council of Museums (ICOM), a museum is "a non-profit making, permanent institution, in the service of society and of its development, and open to the public, which acquires, conserves, researches and communicates, and exhibits for the purpose of study, education and enjoyment, material evidence of people and their environment". This definition, generally accepted in the museum world, clearly emphasises the non-profit nature of museums, describes their main activities (acquisition, conservation, research, communication, and exhibition) and, in a broad sense, their purposes (study, education, and enjoyment). It is very easy, at this stage, to perceive the difficulty of measuring the performance of a museum for the following three reasons:

- firstly, because they deal with a wide range of resources, many of which it is not easy to measure due to their qualitative and heterogeneous nature;
- secondly, because their ultimate purpose is to provide a complex and multiple product, which is not always tangible or commercial in nature;
- thirdly because these institutions are often public or non-profit entities, in which profit may not be measured in solely financial terms and are not, in any case, representative of successful management.

This does not mean that the efficiency of these organizations should not be measured nor that we may not posit alternative tools which allow us to reflect the quality of the work carried out in the museums or, which may at least provide us with an idea of what might be deemed "best practices" in museum management. The findings to emerge from our analyses are useful in themselves for society, which is aware of the need to assess the various public services affecting it. Yet, our findings might also be of use for the governance of museums themselves, since a measure of the relative efficiency of these institutions provides managers with a benchmark reflecting the successful running of museums. The outcomes to emerge may also provide justification for allocation of public funding and prove a useful guide to potential sponsorship.

Based on this, a museum's activity may be regarded as one of production, involving input such as work, provision of buildings and equipment, together with the museum collection itself, in order to obtain various goods and services, corresponding to the main tasks allocated to a museum: conservation, research and exhibition of cultural heritage. Hence the interest in assessing the efficiency of this kind of institution, as an example of one specific case of efficiency analysis within the public sector, as with other sectors similar in nature, such as health, education or justice.

Studies conducted into museum efficiency may be divided into two groups. The first covers works aimed at measuring a museum's performance by drawing up a series of indicators (performance indicators) and includes works by Ames [15], Jackson [16] and Weil [17]. The goal is to select a set of indicators or ratios enabling comparisons to be drawn among various museums for the activities chosen. However, this technique does not provide any ranking of the items analysed. The second group of studies endeavours to measure the efficiency of a set of units using so-called frontier techniques. Some examples of works belonging to this group are Paulus [18,19], Taalas [20], Mairesse and Vanden Eeckaut [21], Pignataro [22] and Basso and Funari [23]. These approaches provide a straightforward indicator allowing comparison between museums, and not merely between activities. A museum is felt to undertake an economic activity in which certain inputs or resources are transformed into outputs or performance. The problem lies in attempting to define this transformation process, an obstacle which may be overcome through the use of parametric or non-parametric models.

Non-parametric models are usually used to measure the relative efficiency of service producers where the use of parametric approaches would prove more restrictive, through the need to specify a functional mathematical relation between input and output. Non-parametric efficiency analysis, Data Envelopment Analysis (DEA), and one of its derivatives, Free Disposal Hull (FDH), have often been used to assess public services thanks to their flexibility, since they impose less restrictive conditions on the reference technology, and can easily be adapted to multiproduct scenarios. These models allow for the calculation of efficiency indicators through the use of multiple models of linear programming, based on the data from a series of units to be assessed.

Our work falls within the second group of studies, non-parametric efficiency analysis using the DEA method of a regional system of museums in Spain, specifically those in the region of Castilla y León (Fig. 1) used as a prototype case study for its significance and the diversity within its museum network. The methodological approach adopted in our research involves a previous selection process, classification and grouping of regional museums, as it is common to find a wide array of museums in any regional system, both in terms of the nature of the collections and the institutional organisation or legal status, as well as the managerial approach. Some museums comply

Fig. 1. Location of Castilla y León in Europe: a prototype case study of a regional system of museums.

more strictly with the requirements of the ICOM definition of a museum, whereas others adopt a more flexible approach. In order to address the classification and selection process of regional museums, we firstly used principal component analysis multivariate statistical techniques to synthesise information from the numerous variables which characterise these institutions. Secondly, we employed cluster analysis to generate homogeneous groups within the regional system of museums. Based on this classification, we applied the DEA method for analysing intergroup efficiency of regional museums.

As a result, the methodological approach to this research involves two inseparable techniques: multivariate statistical analysis to filter the database and DEA to calculate the efficiency indices. The paper will logically follow this order in experimental section, by first typifying and classifying the regional system of museums, prior to analysing their efficiency. We conclude the paper by providing conclusions concerning the implications these findings might have for museum management and the public allocation of resources in this area.

2. Experimental section

2.1. Sorting and classification of the regional system of museums

The region of Castilla y León, which is an autonomous community forming part of Spain, is divided into nine provinces. Its 94,224 km^2 make it the largest region in Europe and one which boasts an abundant and varied cultural heritage thanks to its long and rich history. By way of one of the most striking examples, it is particularly worth mentioning the seven UNESCO declarations of World Heritage Sites, accounting for 16% of all nominations put forward in Spain, and the near 1700 declarations of Assets of Cultural Interest, the most common instrument for the protection of heritage, and which serve to indirectly indicate the cultural value of the various elements of historical artistic heritage.

Museums in this region are obviously one of the clearest representations of its cultural heritage, and include some of the most emblematic national museums belonging to the Ministry of Culture or National Heritage, together with those which form part of the Network of Museums managed by the regional government (Junta de Castilla y León), the traditional museums for fine arts and archaeology in the provincial capitals, together with a small number of museums of different kinds set up or promoted by the regional administration over the last few years.

One outstanding feature of museums in the region is the overwhelming dominance of church-owned museums, which account for 34% of the total number, followed by those managed by local administration, 25%, most of which are ethnographic. A significant number of these are located in small or medium size towns. The spread of museums in rural areas reflects the desire of local administration to bring together and protect local cultural heritage, as well as the most representative signs of its identity, a goal which it is felt can be achieved through the creation of these local collections. Evidently, the small-scale and somewhat peculiar management system implemented in many of these facilities often makes it difficult to determine whether or not they may be termed museums in the strict sense of the word.

Whatever the case, this research aims to cover all the museums included in the study region prototype, on the basis of which our goal is to classify and sort using objective criteria, regardless of the institutional nature of the museums. Our ultimate purpose is to analyse the efficiency of the homogeneous groups. Our work is founded on a database of museums which has involved an exhaustive compilation using various sources of information, principally the Census on museums undertaken by the Ministry of Culture, regional Tourist Office at the Regional Government of Castilla y León and the *Fundación Siglo para las Artes* in Castilla y León, coupled with a fairly flexible definition of what constitutes a museum facility. In other words, all of those institutions that house a permanent collection of movable material items intended for public display and which have sufficient means to achieve the stated aim. This selection criterion has meant including some collections which are of unusual interest but about which scarce information is available concerning variables that characterise museums. This has entailed certain general problems, as we shall see later.

Table 1 contains the basic information on the Census of Museums in Castilla y León together with the distribution by provinces. This yields an initial total of 224 museums, on which a survey was conducted to gather information, both in terms of visitor demand, and characterisation of offer as well as other variables related to the management of the institution concerned. The number of responses varied, averaging above 60%, although it was felt that the museums who did respond provided us with a broad cross-section of the museums in the region, since the

Table 1
Supply and demand for a regional system of museums in Castilla y León, Spain (2004).

Provinces	Database	Museums	Visitors	Limited offer	Visitors
Ávila	11	4	61,212	3	61,212
Burgos	31	17	607,024	9	174,574
León	35	19	477,902	12	227,013
Palencia	26	12	96,934	10	72,323
Salamanca	24	13	202,046	8	177,805
Segovia	17	10	133,341	6	118,487
Soria	25	7	23,430	5	23,430
Valladolid	44	25	376,501	16	247,288
Zamora	11	8	130,690	7	67,681
Total	224	115	2,109,080	76	1,169,813

Source: own elaboration.

replies received included most of the state-run regional museums, together with virtually all relevant ecclesiastical museums, and a wide range of new museums, many of which are run by not for profit sponsors and foundations. Thus, we were left with an initial total offer numbering 115 regional museums that keep a reliable record of the number of visitors, such that annual demand has been put at nearly two million visitors for 2004.

However, as pointed out earlier, not all the museums provide information on each of the variables required in the survey, principally those concerning size, available equipment and admission to the museum. This led to their necessary exclusion for statistical analysis of grouping and efficiency studies, such that the final sample of museums on which analyses have been carried out comes down to 76 museums, 34% of the original database, but 66% of what is regarded as museums keeping a record of visitors. The high representation of this limited sample is to be expected, since it is assumed that those museums not responding to specific questions lack the sufficient management structure, found in better established museums. These museums also account for 55% of the total demand in terms of cultural tourism to emerge from visits to the region's museums. The geographical spread of the supply and demand for museums in the region may be seen in Figs. 2 and 3 , respectively, reflecting the relative dispersion of the museum network together with a certain concentration, above all in demand, in the provincial capitals and main tourist areas, for example Valladolid, Burgos, Salamanca and Segovia.

The variables reflecting the various features of regional museums are shown in Table 2 and aim to be representative of the input and output linked to what would be the production function of a museum. On the one hand, on the input side, we have the factor linked to work or staff employed in the various activities a museum is engaged in (administration, technical staff, security, and so on); the capital factor, here specified in two variables related to size (number of rooms and museum area in square metres) as well as an indicator for equipment and museum facilities (reflecting the existence of library facilities, archives, a restoration workshop, museum guide, storage room, webpage, conference room, cafeteria and souvenir shop); together with other variables representing access, such as opening hours

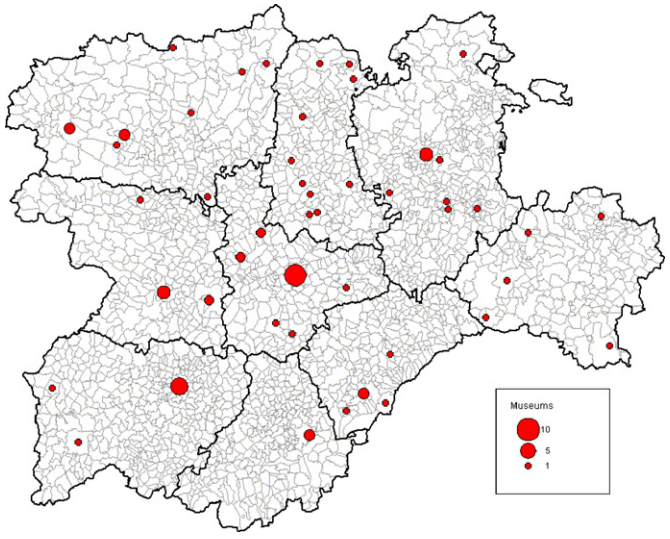

Fig. 2. Regional offer of museums. Limited sample considered in the empirical study (number of museums per town, 2004).

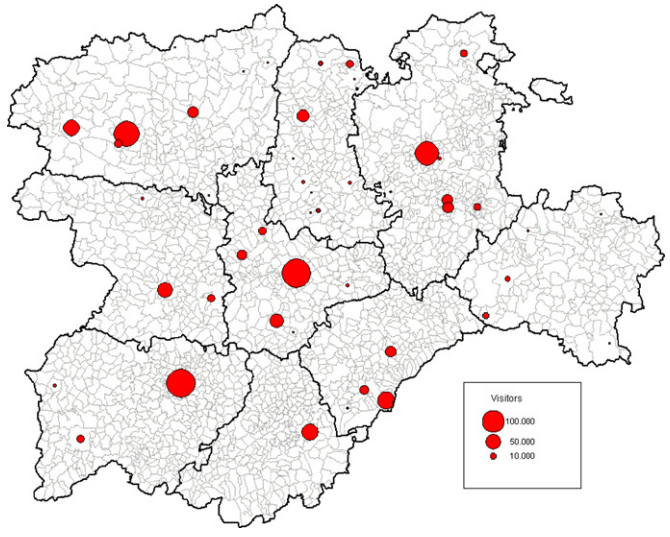

Fig. 3. Regional demand for museums. Visitors in the regional system of museums considered in the study (visitors per town, 2004).

Table 2
Descriptive analysis of the different variables for the regional museum network.

Variable	Maximum	Minimum	Mean	Standard deviation
Staff	23	0	4.42	5.28
Size (rooms)	20	1	5.13	4.51
Size (m^2)	15,904	20	1272.69	2581.45
Equipment	9	0	4.01	2.29
Winter opening hours	56	0	29.04	15.65
Summer opening hours	60	0	32.09	14.96
Admission	9	0	1.71	1.43
Social impact	40	0	4.33	6.27
Collection impact	3	0	1.25	1.11
Visitors	99,185	100	15,392.30	20,373.70

Source: own elaboration.

Table 3
Principal component analysis of the regional system of museums.

Factor	Eigen value	Variance (%)	Accumulated variance (%)
1	3.8949	43.28	43.28
2	1.2669	14.08	57.36
3	1.0808	12.00	69.36
4	0.7860	8.73	78.09
5	0.5621	6.25	84.34
6	0.5371	5.97	90.31
7	0.4254	4.73	95.04
8	0.3346	3.72	98.76
9	0.1121	1.24	100.00

Source: own elaboration.

and admission price. In this section, we have not included any variable representing the cultural value of the actual museum collection itself, as this would be a qualitative variable. However, the impact of this factor is felt to be directly linked to the value of the remaining variables, both for input and output.

As regards variables representing museum output we firstly consider the basic indicator of the number of visitors, namely demand for a museum exhibition. Secondly, we look at impact indicators, one linked to the effect of the museum's activities in society (catalogues, seminars, educational workshops, agreements with various institutions, and so on), and another which emerges from the impact of the museum collection itself (borrowed works, new acquisitions and temporary exhibitions). These two types of indicators have been termed social impact of the museum and impact of the museum collection, respectively.

Based on the restricted sample of museums considered in the research and the characterisation variables outlined earlier, we applied multivariate statistical techniques to sum up the information from the data matrix and sort the study units into homogeneous groups. Table 3 shows the results to emerge from principal component analysis applied to the museum matrix, with variables linked exclusively to the internal management of the museums. In other words, we have voluntarily excluded the number of visitors, as we feel that demand may be determined by the size of the town or city as well as the tourist appeal of the areas where the museums are located. In short, our aim is to achieve a suitable synthesis of the variables related to the management of the museums' activities, in order to subsequently determine coherent groupings, without being conditioned by visitor demand and external factors which may impact it. Our desire to synthesise was achieved since the three principal factors, a linear combination of the original variables, account for 69.36% of the variance. It should be mentioned that logarithms have been taken of variables of size in square metres and data linked to museum opening hours to avoid a scaling effect.

Further, the high Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and the result from Bartlett's sphericity test (Table 4) evidence that the data used adapt perfectly to multivariate applications, and the communality of the variables is quite high (Table 5), implying that they are well-represented through the factors. In sum, these indicators ensure the adequate quality of the principal component analysis performed.

Table 4
Principal component analysis: KMO statistics and the Bartlett coefficient.

KMO measure of sampling adequacy		0.771
Bartlett's sphericity test	Approximate Chi-squared	277.714
	gl	36
	Sig.	0.000

KMO: Kaiser–Meyer–Olkin. Source: own elaboration

Table 5
Principal component analysis: communalities of the variables.

Variable	Communality
Log (winter opening hours)	0.852747
Log (summer opening hours)	0.839724
Staff	0.703345
Social impact	0.681605
Size (rooms)	0.680643
Log (size m^2)	0.680092
Collection impact	0.677928
Admission	0.566848
Equipment	0.559677

Source: own elaboration.

As a result of the correlations of the variables with the principal components after Varimax rotation of the factorial results matrix (Table 6), we may offer the following interpretation of the meaning of these factors:

- first factor relates to the museums' conditions of accessibility, as it reflects the opening hours for both winter and summer, together with the entrance fee. The conclusion to emerge here is that the better established a museum is the more tightly controlled these two areas are;
- second factor shows the most significant variables of a museum's main activities and tasks, such as provision of staff, management of museum equipment and facilities as well as tasks related to the impact of a collection and making its activities known to the public. This factor is thus regarded as a museum's activity;
- third factor is directly linked to the size of the museums, as the highest correlations appear both in the number of rooms as well as in the size of the museum in square metres.

Table 6
Interpretation of principal components of the regional system of museums.

Variables	Factor 1	Factor 2	Factor 3
Log (summer opening hours)	0.8737	0.2585	0.0975
Log (winter opening hours)	0.8700	0.2988	0.0807
Admission	0.6280	−0.0711	0.4092
Social impact	0.1109	0.8150	−0.0709
Collection impact	0.1431	0.7463	0.3170
Staff	0.1124	0.6819	0.4752
Equipment	0.4409	0.5963	0.0985
Size (rooms)	0.0195	0.2318	0.7915
Log (size m^2)	0.3623	0.0670	0.7378

Varimax rotation.
Source: own elaboration.

Table 7
Characterisation of homogeneous groups within the regional system of museums.

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Staff	13.54	4.50	3.20	1.50	2.21	0.56
Size (rooms)	10.46	7.70	2.55	7.10	2.57	2.11
Size (m^2)	2369.54	3689.39	557.20	1226.53	213.00	292.78
Equipment	6.23	4.60	5.10	2.00	3.07	1.44
Winter opening hours	42.08	34.50	36.98	27.05	21.14	0.00
Summer opening hours	43.38	38.75	39.70	31.15	25.21	3.22
Admission	2.68	2.27	1.87	1.95	0.87	0.36
Social impact	11.00	2.60	5.80	0.90	2.21	0.44
Collection impact	2.69	1.90	1.30	0.50	0.64	0.11
Visitors	32,057.70	19,890.70	17,654.00	5954.60	8493.93	2512.67
Number of museums	13	10	20	10	14	9

Mean variables for each cluster.
Source: own elaboration.

With the factorial scores for each museum, we performed cluster analysis to obtain homogeneous groups using Ward's linkage method. Bearing in mind the disperse nature of the regional system of museums, the classification considered to be most appropriate yielded a six group formation, which we now describe through the mean characterisation variables of each cluster (Table 7). The homogeneous groups of the museums are the following.

2.1.1. Ideal museum

These are the museums which achieve the highest factorial scores and the best ratios in all the variables (cluster 1). These museums are well staffed (with an average of 13 employees per museum), well equipped and enjoy good facilities in addition to having well-controlled and wide-ranging opening hours. These resources mean that the museums are also in a position to achieve the highest levels of social impact in their activities, impact in their collections and exhibits and obviously able to attract the greatest number of visitors. They are also quite large museums and in short are the best organised and probably most efficient within the regional system as a whole. In total they number 13 and include eight museums belonging to the Regional Network of Museums, four having been opened fairly recently (Table A.1).

2.1.2. Intermediate museums

These are museums which reach an intermediate position in the characterisation variables, for example in the staff who run the museum, some three or four people, adequate facilities and equipment, and with controlled opening hours. The number of visitors to these museums is quite high and is above the regional average and both the collections they house together with the social activities they undertake have a significant impact. This group includes the remaining museums in the province in addition to those forming part of the Regional Network, together with some of the most emblematic ecclesiastical museums (cathedral museums and others), as well as a small number of successful monographic museums. In general terms this group may be subdivided into two, basically depending on the size of the facilities: cluster 2 includes medium-large museums, totalling 10; and cluster 3 those which are somewhat smaller but which have a greater social impact, numbering 20 (Tables A.2 and A.3).

2.1.3. Embryonic museums

This is a group of museums whose figures are below the regional average in all the characterisation variables. In other words, they have few staff, little equipment and irregular or sporadic opening times. Another significant factor is the admission charge, which is very low, and at times free. Despite this, the number of visitors is quite significant as, to a certain degree, is the impact of some of the social activities the museum engaged in. This group chiefly comprises ecclesiastic and ethnographic museums in rural areas, together with a few monographic and small-scale museums in urban areas. This group may also in turn be split into two groups: cluster 4, larger museums with few visitors; and cluster 5, smaller museums but with larger numbers of visitors, totalling 10 and 14, respectively (Tables A.4 and A.5).

2.1.4. "Irregular" museums

This is the final grouping, cluster 6, which includes the least well-organised and sporadic museums, as they barely meet the requirements for exhibiting and maintenance in what might be termed museum in the strictest sense of the word. There are nine such museums located in rural areas (Table A.6).

2.2. Efficiency analysis of the regional system of museums

Based on the classification of the regional system of museums in Castilla y León outlined in the previous section, put together using objective grouping techniques such as principal component analysis and cluster analysis, we subsequently carried out an analysis of intragroup efficiency using the DEA approach. Our aim was to ensure maximum homogeneity among the units to be compared since DEA provides a stratified indicator reflecting comparative degrees of efficiency among the various decision units, in our case, museums.

Initially, DEA is a non-lineal mathematical technique to determine the efficiency of organizations which handle different inputs to obtain one or more outputs, and basically offers a generalization of traditional approaches based on

productivity indicators for service suppliers. The advantages of this method hinge on the fact that it does not require specifications in the behaviour model of the decision units, nor explicit functional forms of the production function, as the approach basically consists of a simple definition of a production frontier comprising the best units, prior to quantifying how efficient the rest of the sample is in relation to distance from the frontier.

The original DEA estimator proposed by Charnes et al. [24], referred to as the CCR formulation, is the one that allows the efficiency of any Decision Making Unit (DMU, museum for us) to be measured from the maximization of a ratio of weighted outputs with respect to weighted inputs, subject to the restriction that similar ratios for the rest of the DMU are less than or equal to the unit. More precisely, the linear calculation program would be:

Min θ_0

Subject to:

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{r0};\ \ r = 1,\quad \ldots, s$$

$$\theta_0 x_{i0} - \sum_{j=1}^{n} x_{ij}\lambda_j \geq 0;\ \ i = 1,\quad \ldots, m$$

$$\lambda_j \geq 0.$$

This program calculates a virtual unit, as a linear combination, with λ_j weights of all the units evaluated, which obtains an identical or greater number of outputs with a smaller number of inputs than the unit being evaluated. If it is not possible to find a virtual unit that obtains the same outputs with a smaller number of inputs, the unit is efficient and is situated on the frontier.

θ represents the factor that weights all the inputs and takes values between 0 and 1. Efficient DMU will have $\theta = 1$, which means that it is not possible to reduce the number of inputs used to produce an identical level of outputs.

Subsequently, the BCC formulation [25] was created as a proposal for measuring the result of breaking down the efficiency of the CCR formulation into two components: pure technical efficiency and scale efficiency. The measurement of technical efficiency calculated by the BCC formulation makes it possible to find out whether there is proper use of resources in relation with the production of goods or services of the DMU analysed. As for scale efficiency, it is equal to the quotient of BCC efficiency and CCR efficiency, and it provides a measurement of the distance from the DMU analysed to a virtual DMU that operates with the most productive scale size. For this purpose, these authors propose the existence of a single difference between the envelopment of the BCC and the CCR formulations: the inclusion of the restriction of convexity (relating to the DMU k):

$$\sum_{j=1}^{n} \lambda_{jk} = 1.$$

For efficiency analysis of regional museums in Castilla y León (Spain) we considered an extremely simple general formulation of their production function, comprising the basic resources of work and capital, in other words the staff employed at the museum, together with the building expressed in terms of the museum collection and the available equipment. This finally provided us with an asset expressed in the form of the number of visitors to the museum, in other words the output related to the exhibition function. In summary, what we have is an extremely straightforward formulation (three inputs and only one output), which in turn is highly enlightening, for calculating the technical efficiency of this kind of institution.

Efficiency assessment using DEA may be performed through the application of various models: input or output oriented. In our research, we chose the model which we felt best suited our case study, leading us to specify DEA based on minimizing inputs. Using this approach, the results of the efficiency indicator can show to what extent we may improve the use of existing inputs to achieve the same output, or to put it another way, what is the potential of maximum radial reduction of inputs to maintain a given output level.

We chose this type of approach, as we felt that demand in terms of the number of visitors to regional museums is one variable which is not affected by the handling of internal inputs, but is rather determined by reasons such as the size of the urban area where the museum is located and, above all, the tourist appeal of the surrounding area, which is where most tourists and museum visitors really originate from. Moreover, this approach is more suited to a situation of monopolistic markets, because museums may be deemed an example of local spatial monopolies or, at most, a market of different products in a monopolistic competition market, where the units take the output as given and are oriented towards input, in other words, towards natural optimization of cost functions.

The application of DEA to the sample of museums used in this research yields the results summed up in Table 8, which shows the number of efficient and inefficient museums for each homogeneous group in the regional museum network, depending on whether we employ a constant returns to scale

Table 8
Efficiency analysis of the regional museum network: synthesis results using CCR and BCC models.

		CCR Model		BCC model	
	No. of museums	Efficient	Inefficient	Efficient	Inefficient
Cluster 1	13	3	10	6	7
Cluster 2	10	2	8	4	6
Cluster 3	20	3	17	7	13
Cluster 4	10	4	6	6	4
Cluster 5	14	1	13	2	12
Cluster 6	9	4	5	6	3
Total	76	17	59	31	45

Source: Appendix and own elaboration.

Table 9
Efficiency ratios for the regional museum network according to CCR and BCC models.

	CCR Model		BCC Model	
	Mean	Standard deviation	Mean	Standard deviation
Cluster 1	0.56	0.30	0.91	0.11
Cluster 2	0.37	0.33	0.84	0.16
Cluster 3	0.41	0.33	0.74	0.25
Cluster 4	0.55	0.39	0.81	0.25
Cluster 5	0.20	0.27	0.31	0.32
Cluster 6	0.72	0.35	0.96	0.05

Source: Appendix and own elaboration.

approach (CCR model) or variable returns to scale (BCC model). The computer program used in the DEA approach was the Holger Scheel Efficiency Measurement System (EMS) (University of Dortmund), version 1.3. Likewise, Table 9 shows the mean efficiency ratios and the standard deviation for each group of museums, taking account of the two technological hypotheses mentioned and full DEA results for the museums included in the research may be found in Appendix (Tables A.1–A.6).

Taking the first set of results (CCR model), the data show how only 17 museums, 22% of the total, reach the maximum degree of efficiency, in other words constitute the efficiency frontier for each group of museums. This is in fact quite a small list of museums, and is a proportion which is reflected in all the clusters analysed, above all amongst the most consolidated groups of museums, whereas amongst the young and unusual museums the proportion is more erratic. Thus, in the first category (ideal museums), only three of the 13 museums are efficient, the mean efficiency ratio being 56%, indicating that 44% mean inefficiency exists for the set of museums analysed in the first group (Table 9). This inefficiency "gap" is even worse for the second and third groups of intermediate museums, and shows even greater variation for the remaining segments.

This first efficiency slope provides us with information as to the technical improvements which may be made by the various museums in the sample in relation to the "best" units. However, the concept of inefficiency may be explained in several ways, one of which may simply be the poor handling of the inputs, and another the problem of scale. In other words, a proportional reduction in inputs may not yield the same but rather a smaller amount of outputs in proportional terms. When various scales of size exist among analysis units the proportional comparison of large and small units may prove unsuitable, meaning that a variable yield approach may be worth considering. With this application of DEA (BCC model) the synthesis results are shown in Table 8 and, as expected, the number of museums at the efficiency frontier has widened in overall terms to 31, namely, 41% of regional system of museums. The proportion of efficient museums has virtually doubled in all the categories analysed (a complete list of museums with this technological hypothesis appears in the Appendix), indicating a substantial increase in the mean efficiency ratios, as reflected in Table 9. For instance, in the first category of museums, six out of 13 are now efficient, the mean efficiency ratios reaching 91%, indicating that mean inefficiency is only 9% in this range. These improvements in efficiency are also apparent in the intermediate and embryonic categories of museums, even when the advances in the average ratios are lower. This is due to the greater heterogeneity of museums in these categories, where almost 50% of inefficiency may be accounted for by the size in which they are operating (see scale inefficiency ratios in the Appendix).

Finally, DEA is not able to order efficient centres, as they are all allocated a value equal to one. However, one way of ranking these units would be to run an Andersen and Petersen [26] superefficiency model. This approach also uses a linear programming algorithm similar to conventional DEA, yet sidesteps any ties among efficiency scores by discarding linear programming restrictions of the efficient unit in question. Thus, for inefficient elements, the value remains stable, whereas among the efficient scores the slope varies depending on the "range" of resources necessary to maintain efficiencies when obtaining the product. The application of this approach to the sample of museums considered in the current work is shown in the Appendix, where the ranking of efficient museums can be seen. However, when superefficiency results are exaggerated, the suspicion arises that these units may be behaving unusually, or that they are elements whose behaviour shows a tendency to dominate. In other words, their presence has an influence over the other results in the analysis. Should this prove to be the case, our research may suggest future directions for the analysis of reference museums and their possible impact on guidelines for optimal management strategies.

3. Conclusions

Efficiency assessment of heritage institutions is as yet a relatively unexplored and untapped field, although in fact many of these institutions may be considered as prototype public bodies using different inputs, which may not always be measurable in objective terms, providing a complex, at times intangible and non-commercialising output. In short, this efficiency evaluation deals with a public service, similar to education or health, which have been the focus of so much attention in recent years in public sector efficiency analysis.

However, what is particular to the heritage sector is that it is characterised by the wide diversity of the institutions, even when we confine ourselves to such a specific area as museums. This is due to the particular nature of the themes and differing size of the various museum facilities, as well as the complexity and range of organizational systems in operation. For these reasons, it is advisable to merge the classification and segmentation approaches used on the initial database, together with the techniques employed to measure the efficiency of public institutions.

This research offers the results from a classification study and analysis of the efficiency of a regional network of museums in Spain, using a wide and representative sample of 76 museums, in both rural and urban areas in the region of Castilla y León. Various multivariate analysis techniques have been used to synthesise the initial information and achieve a

homogeneous grouping of the decision units based on variables linked exclusively to museum management, for subsequent use in DEA to evaluate efficiency following a guided input model.

Among the most salient results to emerge from the research we may first point to having achieved an efficiency frontier within the regional network of museums, comprising optimal bodies in each homogeneous segment of museums, as well as establishing the efficiency gap compared to the other facilities. We thus verified the usefulness of the DEA method for comparing the efficiency of cultural facilities and, particularly, for providing an ordered classification of the decision units in agreement with the degree of efficiency when handling the inputs. By way of a specific remark on the network of museums analysed, it should be pointed out that museum management is inefficient in general terms, as only 22% of museums in the region may be deemed to offer optimal management, a result which concurs with other known works in the field [18,22,23]. Nevertheless, given the disparity in the size of the museum facilities, a variable scale return approach dependant on museum production should be considered, in which case efficiency outcomes improve substantially, both in terms of establishing the efficiency frontier, now reflected by 41% of the regional system of museums, as well as the mean efficiency ratios, which improve substantially in all the groups. It is noticeable that in intermediate museums gains are lower due to increased heterogeneity in size and inputs, such that the scale inefficiency ratios are greater for this group. In sum, removing the irregular and embryonic type museums, data for which may prove somewhat erratic, it appears that prior sorting and classification of the museums reflects a general order of the efficiency results, in the sense that the best equipped and most carefully managed are those which achieve the best efficiency data, as is to be expected.

The results to emerge from research of this nature are not restricted to merely providing objective and rigorous knowledge of the efficiency of a regional network of museums covering a wide and heterogeneous group, but may also yield an opportunity for cooperation between analysts and decision-makers involved in the heritage sector. Firstly, the museum managers themselves may gain a relative measure of the efficiency of their management by applying this approach. Secondly, those charged with cultural policy may benefit from an objective tool for allocating museum resources, either through providing funding for efficient groups, or more imaginative solutions, such as the creation of efficiency bonuses dependant on management outcomes. Finally, this classification may help private agents and particularly sponsors to gain an idea of the viability of their sponsorship activities in heritage [27].

DEA is unlikely to resolve all the problems that arise when dealing with such complex institutions as museums. Yet, the benefits to emerge from the application of this approach should provide an incentive to further consider the production process of museums and how it may best be modelled. Any progress made in this field must go hand in hand with a suitable empirical approach able to reflect the complexity of the museum production process.

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Appendix. Museums included in the research and results of DEA, 2004 for each cluster.

Table A.1
Cluster 1.

Key	CCR DEA	BCC DEA	Superefficiency
SA15 Museo Art Nouveau y Art Deco	1.00	1.00	Large
LE18 Museo de León	1.00	1.00	1.71
AV04 Museo de Ávila	1.00	1.00	1.32
VA18 Centro Etnográfico Joaquín Díaz	0.55	1.00	1.43
VA39 Museo Oriental	0.47	1.00	2.43
VA33 Museo de Valladolid	0.16	1.00	1.25
SE16 Museo de los Ángeles	0.54	0.95	0.95
VA29 Museo de la Ciencia	0.81	0.90	0.90
ZA11 Museo de Zamora	0.24	0.84	0.84
SA18 Museo de la Automoción	0.63	0.84	0.84
BU04 Museo de Burgos	0.20	0.84	0.84
SE09 Museo A.C. Esteban Vicente	0.34	0.80	0.80
VA40 Museo Patio Herreriano de A.C.	0.34	0.61	0.61
Mean efficiency	0.56	0.91	
Scale efficiency[a]	0.62		
Scale inefficiency[a]	0.38		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

Table A.2
Cluster 2.

Key	CCR DEA	BCC DEA	Superefficiency
LE03 Museo de los Caminos	1.00	1.00	Large
SO09 Museo Catedralicio B.O.	1.00	1.00	Large
VA03 Museo del Ayer	0.22	1.00	2.82
PA26 Museo Santa Eulalia	0.08	1.00	1.30
BU02 Centro de Arte Caja Burgos	0.44	0.91	0.91
PA09 Centro Interpretación Minería	0.31	0.79	0.79
LE25 Museo del Bierzo	0.29	0.77	0.77
PA21 Museo de Palencia	0.09	0.77	0.77
LE26 Museo del Ferrocarril	0.12	0.62	0.62
BU20 Museo de las Merindades	0.17	0.56	0.56
Mean efficiency	0.37	0.84	
Scale efficiency[a]	0.44		
Scale inefficiency[a]	0.56		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

Table A.3
Cluster 3.

Key	CCR DEA	BCC DEA	Superefficiency
BU25 Museo de la Asunción	1.00	1.00	Large
SE02 Museo Tecnológico del Vidrio	1.00	1.00	Large
BU14 Museo de la Colegiata	1.00	1.00	4.17

Table A.3 (*Continued*)

Key	CCR DEA	BCC DEA	Superefficiency
LE04 Museo del Chocolate	0.83	1.00	1.18
VA10 Museo de Ferias	0.72	1.00	1.23
PA28 Villa Romana de la Olmeda	0.59	1.00	1.03
AV03 Museo de Arte Oriental	0.21	1.00	1.02
VA06 Museo Santa Eufemia	0.01	0.97	0.97
SO13 Museo de Tiermes	0.29	0.86	0.86
AV07 Museo Policial	0.33	0.81	0.81
PA14 Museo Etnográfico Piedad Isla	0.19	0.75	0.75
BU23 Museo de Dinosaurios	0.27	0.67	0.67
LE33 Museo Batán	0.52	0.65	0.65
LE24 Museo de la Radio L. del Olmo	0.42	0.52	0.52
VA09 Museo S.M. de Mediavilla	0.10	0.48	0.48
LE05 Museo Romano	0.14	0.48	0.48
ZA10 Museo de la Semana Santa	0.39	0.43	0.43
SA19 Museo de la Radio	0.07	0.41	0.41
VA34 Museo S. Joaquín y Sta. Ana	0.11	0.38	0.38
VA07 Museo de Semana Santa	0.10	0.33	0.33
Mean efficiency	0.41	0.74	
Scale efficiency[a]	0.56		
Scale inefficiency[a]	0.44		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

Table A.4
Cluster 4.

Key	CCR DEA	BCC DEA	Superefficiency
PA06 Museo Palacio Don Pedro I	1.00	1.00	Large
SA06 Museo Catedralicio Ciudad Rodrigo	1.00	1.00	Large
SA25 Museo Taurino de Salamanca	1.00	1.00	1.17
ZA09 Museo Catedralicio de Zamora	1.00	1.00	1.00
ZA06 Museo de Sancti Spiritus	0.56	1.00	1.00
PA02 Museo San Miguel Arcángel	0.14	1.00	1.00
SE14 Museo Rodera y Robles	0.11	0.67	0.67
PA10 Museo de Santa María	0.14	0.60	0.60
VA41 Museo de Ciencias Naturales	0.42	0.42	0.42
VA28 Museo Academia de Caballería	0.17	0.39	0.39
Mean efficiency	0.55	0.81	
Scale efficiency[a]	0.69		
Scale inefficiency[a]	0.31		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

Table A.5
Cluster 5.

Key	CCR DEA	BCC DEA	Superefficiency
SA21 Museo de las Úrsulas	1.00	1.00	Large
BU05 Museo de Farmacia	0.53	1.00	Large
VA19 Museo de Campanas	0.46	0.69	0.69
SE07 Casa Museo Antonio Machado	0.21	0.29	0.29
SA07 Museo Arqueológico de Lumbrales	0.16	0.29	0.29
BU11 Monasterio San Pedro de Cardeña	0.12	0.25	0.25
SO14 Museo de los Pastores	0.04	0.23	0.23

Table A.5 (*Continued*)

Key	CCR DEA	BCC DEA	Superefficiency
ZA04 Museo S. Salvador de Caballeros	0.10	0.18	0.18
ZA08 Museo Baltasar Lobo	0.11	0.14	0.14
VA26 Fundación S. y Santiago Montes	0.06	0.10	0.10
SE17 Pinacoteca de Arte Contemporáneo	0.03	0.10	0.10
SO21 Museo Concatedral de San Pedro	0.02	0.06	0.06
PA08 Museo Etnográfico de Autilla Pino	0.00	0.05	0.05
VA27 Museo de Anatomía Humana	0.00	0.04	0.04
Mean efficiency	0.20	0.31	
Scale efficiency[a]	0.65		
Scale inefficiency[a]	0.35		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

Table A.6
Cluster 6.

Key	CCR DEA	BCC DEA	Superefficiency
BU07 Museo del Retablo	1.00	1.00	Large
LE34 Museo Parroquial de Valderas	1.00	1.00	Large
SA14 Convento de Santa Clara	1.00	1.00	Large
ZA02 Colección de Petavonium	1.00	1.00	7.26
LE11 Museo Etnográfico de Casares	0.83	1.00	2.50
PA13 Casa Museo de San Martín	0.94	1.00	1.28
LE28 Museo Minero Ferrería San Blas	0.28	0.93	0.93
SO11 Colección Etnográfica Iruecha	0.36	0.88	0.88
LE27 Museo Etnográfico de Prioro	0.07	0.87	0.87
Mean efficiency	0.72	0.96	
Scale efficiency[a]	0.75		
Scale inefficiency[a]	0.25		

DEA: Data Envelopment Analysis. Source: own elaboration.
[a] Scale efficiency: CCR/BCC; scale inefficiency: 1 – scale efficiency.

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