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**Indexes of creativity: A measurement
proposal for Spain and its Autonomous
Communities**

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Abstract The interest which the creative economy and how it may be measured has aroused in recent years reflects the impact this has had on employment and wealth not only in developed but also in developing countries; hence the timeliness of analysing how it is measured in economies which display major regional inequalities. The present work addresses the issue of creativity linked to the notion of innovation, yet adopting a culture based approach. The paper pursues a two-fold objective: on the one hand, it aims to draw up a creativity index for Spain and its autonomous communities (AC) based on the adaptation of the KEA Report Creativity Index (2009) published by Martín, Palma and Martínez. (2014) and, on the other hand, to estimate the proposed index of creativity using the methodological technique of Data Envelopment Analysis (DEA).

To achieve this, various representative indicators are defined, grouped into components that impact on creativity. These indicators are formative, technological and innovation, social diversity, labour, institutional, as well as others related to cultural supply and demand. Sources are drawn mainly from the National Statistics Institute and Ministry of Education, Culture and Sport, taking the years between 2005 and 2010 as the reference period. The paper contributes to the empirical literature addressing indexes of creativity in Spain, which remains scarce, and aims to provide deeper insights into the creative component from a standpoint which is comprehensive, yet which focuses on the cultural element. In addition, based on these indicators, the strengths and weaknesses of the creative economy in each AC can be determined with a view to providing tools that will prove useful for cultural policy decision-making

Keywords: indexes of creativity, innovation, cultural sector, Data Envelopment Analysis, Spain

JEL: Z10; O30; O31, R11

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1. Introduction

Over the last few years, creativity has become an emerging paradigm which has been subject to analysis from a multidisciplinary perspective that embraces psychologists, geographers, town planners, cultural economists and scholars of economic development, and which now lies at the heart of scientific debate. As pointed out by Correia and Da Silva (2014), creativity is a complex and multidimensional concept, such that there is no single definition which covers it in its entirety. Yet, creativity, perceived as the process of creating something new which generates value, had not been the subject of economic research until quite recently, precisely because no economic value had been attached to it.

As pointed out by Boix and Lazzeretti (2012), creativity has become a topic for economic enquiry thanks in part to two important contributions: the publication by the Department of Culture, Media and Sports (DCMS) of The Creative Industries Mapping Document (1998, 2001, 2009) which defines the creative industries as “*those activities based on creativity, competences, individual talent and innovation, and which display the potential to create wealth and employment by generating and exploiting intellectual property*”(DCMS, 2001,5), and secondly Florida’s publication in 2002 of the work *The Rise of the Creative Class*, which focuses its attention on the human factor, based on the idea that all human beings are creative in some way and that said creativity only needs to be channelled for it to create value. Since then, studies into the creative economy have abounded (based on wealth and on intangible value: knowledge, know-how, intellectual property, talent, relational capital) aimed at gauging the impact it has on an area; hence, the efforts to measure it, not without there having been a prior debate concerning the terms in which the creative sector should be delimited both in the academic as well as institutional domain (DCMS 2001, KEA 2006, UNCTAD 2008, European Commission (2010) Howkins 2007; O’Conor 2007, Markusen et al. 2008;, Flew and Cunningham 2010, Lazzeretti , Boix and Capone (2008, 2012, 2013), Boix et al. (2013), amongst others).

Creativity has also come to the fore in institutional terms as evidenced by the KEA report for the European Commission (2006, 2009) and by the United Nations Creativity Economy Report (UNCTAD 2008, 2010, 2013), which also reflects the importance of the creative economy for developing countries. The relevance of the KEA report (2006) lies in the fact that it was the first time that the Commission had spoken of the cultural and creative sector and that it had made an effort to measure it in financial terms based on its representativeness in terms of GVA and employment for the EU. The Impact of Culture on Creativity (KEA 2009) report addressed the notion of creativity and its various interpretations (artistic, technological and economic creativity) and put forward a proposal to measure the creative sector based on the European creativity index, taking a culture-based approach to the concept of creativity. 2009 was declared the European year of creativity and innovation, and strove not only to raise awareness of the importance of these concepts but also how they can contribute to economic growth as well as individual and social welfare.

The interest which the creative economy (at the heart of which lies creativity) has aroused in recent years and how it may be measured reflects the impact it has had on employment and wealth not only in developed but also in developing

countries; hence the timeliness of analysing how it is measured in economies which display major regional inequalities. This makes the creative economy a strategic economic sector open to public policies aimed at enhancing welfare and accounts for why it needs to be measured.

Although we have cited the (2009) KEA report as a key point in the institutional importance of measuring the creative sector, efforts to construct indexes of creativity commenced with the work of Florida (2002) who built a creativity index based on the distribution of the creative class, grounded on the model of the 3Ts (talent, tolerance and technology) that was to provide the basis on which subsequent indexes of creativity were to be founded.

One interesting study which reviews the various contributions made towards measuring creativity using indicators is that of Correia and Da Silva (2014) who provide a chronological summary of the main indexes of creativity constructed since Florida's index in 2002. For this, they compare a total of 12 indexes, exploring the relative strengths and weaknesses of each, prior to offering a new global creativity index for Europe, the Creative Space Index, based on the dimensions that make up the previous indexes (Talent, Openness, Cultural Environment and Tourist, Technology and Innovation, Industry, Regulation and Incentives, Entrepreneurship, Accessibility and Liveability).

Aside from Florida's creativity Index, other cited authors, in chronological order are The Creative Community Index of Silicon Valley (2002), The European Index of Creativity by Florida and Tinagli (2004), the Hong Kong Creativity Index (2004) that was developed by the Centre for Cultural Policy Research of the University of Hong Kong (2004), The Czech Creativity Index developed by Kloudova and Stehlikova (2007), the Composite Index of the Creative Economy for the Flanders district (Bowen, Moesen and Sleuwaegen, 2008); The Creativity City Index was developed by Fukuoka Benchmarking Consortium (2008), the European Creativity Index by KEA (2009), the Baltimore Creativity Index by Acs and Megysi (2009), Landry's Creativity City Index (2010) for Bilbao and the Bay of Biscay area. The Creativity City Index (2012) was constructed for the Beijing Research Centre for Science, by Hartley et.al (2012), and finally, The Global Creativity Index constructed by Florida et al. (2011).

The indexes analysed by Correia and Da Silva (2014) differ in their application, and range from indexes of geographic distribution at a global scale, and indexes for large spaces such as Europe or the USA, to those which are specific to a country, region, city or small area.

The common denominator underlying the above-mentioned indexes, with the exception of the Fukuoka Benchmarking Consortium, is that they all include the various dimensions analysed by Florida's index (human capital, creative class and education (Talent), openness, diversity, tolerance (Tolerance) and technology and innovation (Technology), although most embrace emerging dimensions in an effort to reflect new creative elements which are characteristic of the area to be analysed and are also conditioned by available data. Some are extensions to other areas such as those designed by Florida and Tinagli (2004) for Europe, and subsequently applied to the USA, or The Global Creativity Index (Florida et al. 2011) for 82 countries, or those devised for a single country, such as the Czech

creativity index, or for a specific area such as the Baltimore Creativity Index, or the index devised by Landry for Bilbao and the Bay of Biscay area.

One of the main weaknesses of the indicators is that, in certain instances, a great deal of them analyse too few dimensions, since they are based on Florida's model, whilst in other cases, they analyse too many, as is the case of the Hong-Kong index (88), the Creativity City Index of Beijing (78) or Landry's (72). Of all of these, the one put forward by KEA (2009) displays a number of weaknesses, which include it not having been tested empirically, since the sources of data are for each country, therefore making inter-country comparisons difficult. In addition, it is also an index of creativity based on art and culture, such that it is grounded on a more specific notion of creativity, and less related to innovation. Said index points to people as the "sources of creativity" and, as the primary source of creativity; the cultural and creative industries, in that they enable creativity to be expressed, materialised and disseminated; the various areas, in which a virtuous circle is generated due to the fact that creative people in turn demand creative products and services and that they tend to group together; and, finally, society, which must take part in the creative process, something which might be achieved through the education system or by regulating intellectual property rights². The fact that this index has not been tested empirically and that it displays greater potential for application to a specific country is what has aroused our interest in empirically testing it for Spain.

In addition to these indexes of creativity based on the human capital theory (creative class), we can also find other regional indexes of creativity grounded on the notion of creative industries, such as those devised by Lazzaretti, Boix and Capone (2008, 2013) for Italy and Spain, or Boix et al. (2013), who explore spatial concentration patterns for Spain compared to other European countries (Italy, France and the UK) based on a *clustering* process which is more focused on business and technological aspects, and built on a coefficient of location taking employment in the creative industries as a variable or for Portugal the work of Figueira (2016).

In addition to the above cited comparative works, for the specific case of Spain and its various autonomous communities (AC), we find several studies which measure creativity: Boix and Lazzaretti (2012) examine the geography of the creative industries based on the figures of added value and employment. Méndez (2012) considers the creative economy in Spain at a municipal level, focusing on Madrid and Barcelona. For the case of Portugal For the case of Spain, mention should also be made of the regression model designed by Casares (2012) which links regional growth based on GDP to the variables of creative capital, talent, tolerance and technology. One adaptation of the KEA (2009) index of creativity based on culture may be found in the work of Martín, Palma and Martínez (2014). As regards indexes of creativity, one recent study is that by Bergua et al. (2016)

² Six dimensions are studied in this case: Human Capital (encompassing indicators linked to education oriented towards the arts and culture and cultural employment), Openness and Diversity (embracing indicators related to attitudes of tolerance, pluralism and interest in other cultures), Cultural Environment (cultural participation, as well as cultural infrastructure (theatres, museums,...), Technology (indicators of broadband and households with a computer and video-console, which prove insufficient), Regulatory incentives to create (including tax breaks, subsidies, direct public spending and intellectual property rights; and, finally, cultural output production which comprises indicators reflecting economic contribution and production in the sector.

for Spain and its AC, and which is also grounded on Florida's model. These studies evidence the concern for measuring the impact of the creative economy in recent years in Spain, following in the wake of the research into the issue at a European scale.

This paper pursues a two-fold objective: first, it aims to draw up a creativity index for Spain and its autonomous communities (AC) based on the definition of the European creative Index de KEA (2009) adapted to Spain using Data Envelopment Analysis (DEA) and, second, to compare the results with those obtained with a Composite Index with equal Weighting on the other hand, to compare the results obtained by adapting the KEA Report Creativity Index (2009) published by Martín, Palma and Martínez. (2014) to Spain and its AC. To achieve this, various representative indicators are defined, grouped into components that impact on creativity. These indicators are formative and cover technological and innovation aspects, together with social diversity, labour, institutional, as well as other matters related to cultural supply and demand.

The paper contributes to the still scarce empirical literature addressing indexes of creativity in Spain and aims to provide deeper insights into the creative component from a standpoint which is comprehensive, yet which focuses on the cultural element. In addition, based on these indicators, we can analyse the strengths and weaknesses of the creative economy in each AC.

Our analysis shows that Aragón, Catalonia, Madrid, Murcia and Navarra are the most "creative" regions according to the composite index drawn up. By contrast, ranking lowest are the regions of Asturias, the Canaries and Castilla-La Mancha. These findings are similar to those obtained in the work of Martín, Palma and Martínez (2014).

The paper is organised as follows. The second section puts forward a proposal for a creativity index for Spain and its AC and is then applied. The third section provides the results, and the final section offers the main conclusions to emerge from the study.

2. Proposal for a creativity index for Spain and the AC

2.1. Methodological introduction and data gathering

As pointed out, the concept of creativity proves complex and encompasses many dimensions. As a result, any effort to calculate an index that reflects the greater or lesser extent to which it is present in a country's various regions clearly involves a degree of subjectivity which cannot be ignored. Yet, this has not prevented the publication of numerous studies which apply several techniques to indexes of creativity in various countries and regions.

Our study focuses on culture-based factors which influence creativity. To do this,

we include a series of indicators which we feel reflect the determinants or which at least favour the emergence of creativity in the various AC in Spain.

Prior to explaining the components included in the index of creativity, we consider some basic aspects to explain the determinants, limitations and restrictions inherent in the model so as to adapt it to the reality of Spain.

Firstly, the areas we study are by no means homogeneous and even though this is a feature of any regional analysis of Spain we feel that highlighting it proves particularly relevant to the case study in hand, given the specific characteristics we aim to explore, since the analysis is grounded on culture-based creativity.

Secondly, for reasons of data availability, the analysis is confined to the 17 Spanish regions, omitting Ceuta and Melilla.

The various components of creativity to be considered are: training, technological and innovation factors, the social context, public sector presence and the cultural dimension of cultural aspects (on both the supply and demand sides). For each of these, we use indicators which can be proxy variables of the respective dimensions. Said indexes are the ones which will be used to devise the index of creativity shown in section 2 of the work.

On key aspect concerns the statistical sources used and the time period. The data used were mainly taken from the National Institute of Statistics and the current Ministry of Education of Culture and Sport. The period analysed in the study was between 2005 and 2010. Said years might be deemed representative since they are, respectively, both before and after the outbreak of the financial crisis to hit Spain and, as a result, might prove indicative of the impact the crisis had on the variable we analyse. Due to data availability, in certain instances the analysis is conducted for a longer time period (2005-2006 and 2009-2010).

2.2. Methodology: DEA

Data Envelopment Analysis (DEA) is a linear programming tool used to evaluate the efficiency of production units characterised by a set of inputs to produce outputs, and which was developed by Charnes, Cooper and Rhodes in 1978.

The idea underlying this technique is to maximise a kind of index of total productivity of factors (output for input relation) for each of the units being evaluated. In this way, the numerator of the index will reflect all the outputs whilst in the denominator all the inputs used in the production process will be aggregated. Subsequently, assuming that it is difficult to find a conventional system of prices, DEA endogenously determines a set of weights so as to maximise the productivity ratio for each unit.

Although application of DEA was initially confined to what was strictly production³, the technique has subsequently been used in other contexts, particularly when constructing composite indicators. Based on the initial proposal of Melyn and Moesen (1991) to evaluate macroeconomic performance and its subsequent adaptations (Cherchye, Moesen and Van Puyenbroeck 2004; Murias et al., 2012) many studies have been carried out in this field (Storrie and Bjurek, 1999, 2000; Cherchye, 2001; Mahlberg and Obersteiner, 2001; Cherchye and Kuosmanen, 2002; Murias, Martínez and Miguel, 2006; Murias, Miguel and Rodríguez, 2008).

In the field of cultural economics there are also examples of creativity being measured by constructing indicators using said technique (Correia and Da Silva 2014; Bowen, Moesen and Sleuwaegen 2008)

The method applied is as follows: let us consider a group of n units and m partial indicators, where $y_{c,i}$ represents the value of the partial indicator i for unit c , with $w_{c,i}$ being the respective weights.

The choice of weights is the solution to a linear programming problem where the target function (composite indicator I_c) is the weighted sum of the partial indicators. The program allocates the weights so as to maximise the target function subject to two restrictions: first, that the value of the indicator is not greater than one for any of the units in order to ensure an intuitive interpretation thereof, and secondly, the weights must be non-negative, such that the composite indicator will be a non-decreasing function of the partial indicators (Cherchye et al., 2007, page 120). In analytical terms, the formulation reads as follows:

$$I_c = \max_{w_{c,i}} \sum_{i=1}^m w_{c,i} * y_{c,i}$$

$$s.a. \quad \sum_{i=1}^m w_{c,i} * y_{j,i} \leq 1 \quad \forall j \in \{1, \dots, n\}$$

$$w_{c,i} \geq 0 \quad \forall i \in \{1, \dots, m\}$$

where w represents the weighting procedures of each of the partial indicators considered (corresponding to the dimensions or components of the index of creativity) and I is the value of the respective partial indicator.

Thus, applying this approach, the maximum value for the synthetic indicator is 1 and the AC which reach said value will be the “most creative” under the partial indicators deemed to be components of creativity. Likewise, the difference between the maximum value and the value of the index for a given region shows the latter’s deficit and its possible margins of improvement.

³ Initially, DEA was a widely used and widely recognised technique for evaluating efficiency in public and private production units (Seiford 1996; Tavares 2002).

Two main advantages of this technique are pointed out; firstly, its objectivity, since, a priori, it requires no allocation of weighting procedures, and secondly, its flexibility, since it allows weights to be chosen individually for each unit. In other words, it does not require that all the units attach the same importance (weight) to a given partial indicator. Despite this “freedom” to allocate weights, should this be deemed excessive, it may be limited by introducing further restrictions on the weighting procedures, as is done in our study.

2.2.1. Clustering components

The work of Martín, Palma and Martínez (2014) adapts the European index of creativity proposed by KEA (2009) to Spain and its autonomous communities. Given the limitations imposed by the availability of information in Spain, Martín, Palma and Martínez (2014) put forward a proposal for adapting the KEA index using 19 indicators corresponding to six dimensions. Our work is based on said proposal, such that we consider the following indicators:

A) Training

What in KEA (2009) is “Human Capital” –comparable to Florida’s “Talent” (2002), even though the latter considers a very broad creative class- has changed to a component of indicators related to education, basically, using students. In other words, the education component takes account of human capital tending towards art and culture, but in its formative stage.

B) Technology and Innovation

“Technology” in KEA (2009) focuses on a more domestic environment, whereas our proposal, which is more closely aligned to Florida’s “Technology”, merges technology and innovation, since the two are closely linked. The two indicators we use for this dimension are related to intensity of R&D on employment (ratio of domestic spending on R&D on a full-time basis) and the presence of patents, which are clear evidence of creativity in the field of innovation, qualified by the scale of employment in the technology sector (ratio of the number of applications for patents at a national level compared to staff working full time in R&D).

C) Social diversity

“Openness and Diversity” in KEA (2009) is one of the most difficult to include. In our study, this has been done through two indicators that might be deemed to approach Florida’s “Tolerance” component, which embraces ethnic minorities and homosexuality. An added difficulty concerns the availability of representative data at a regional scale. One indicator would reflect the percentage of those born overseas and another, the presence of the Roma community, for two reasons, because to a large extent they are involved in supplying flamenco and because they are present in most autonomous communities. Due to the lack of any direct data, the number has been estimated using a publication issued by the Roma

Foundation Secretariat and a regional distribution of the loans awarded by the Sector Committee for Social Affairs for the Roma Development Plan in 2011.

D) Labour

This component has no equivalent in KEA (2009), although cultural employment was taken from its “Human Capital”. In the case of the employment indicator, Cantabria, Extremadura and La Rioja, which appear together in the statistics, have been given the same percentage of cultural employment.

E) The institutional component

This component, which equates to the “Regulatory incentives to create” in KEA (2009), is an extremely complex area. It includes tax breaks, subsidies and intellectual property rights protection. Since our analysis is conducted at a regional scale, no significant empirical evidence is available for each of the autonomous communities. There are obviously differing incentives for innovation at a regional scale, but we do not have this level of information. As a result, and given that all the autonomous communities employ mechanisms of this kind, we used Regional Public Spending data, since the information provided by the state is not broken down into regions. For this component, however, we note the possibility that public spending may displace private initiative, as pointed out by Frey (2002) in his Theory of Congestion, with regard to the elements that make up the creative process.

As mentioned earlier, we were not able to obtain regionalised data on intellectual property rights, as a result of which we opted not to include this indicator. Nor were we able to obtain data concerning cultural associations and foundations, although it would have been useful to have such data available as a further indicator within the institutional component.

F) Cultural component

“Cultural environment” and “cultural output” in KEA (2009) have been merged in our proposal into an indicator of cultural supply and another reflecting cultural demand. The supply indicator chosen is linked to cultural production, in terms of the availability of regional data, and another of cultural dissemination.

On the demand side of culture, we consider that participation in cultural activities is a better indicator of creativity since these are key features of cultural creation that may be likened to the cultural participation present in the KEA (2009) index.

2.2.2. Constructing the Index

To construct the index for each of the dimensions mentioned, we chose those partial indicators which evidenced the lowest correlation such that when finally designing the composite index ten partial indicators were considered. It should be borne in mind that the correlations between indicators led to only one partial indicator being considered for some dimensions (labour and institutional) whereas two were considered for the remainder, meaning that these latter dimensions have

a greater importance in the composite index. In addition, the autonomous cities of Ceuta and Melilla were excluded from the analysis, such that the index was calculated for the 17 autonomous communities.

Table 1 shows the various partial indicators used, together with an indication of the dimensions to which they correspond.

Table 1. Checklist of Index Dimensions and Indicators

DIMENSIONS	INDICATOR	CALCULATION	YEAR	SOURCE
TRAINING	F ₁ Non-university education	Percentage of students corresponding to upper secondary education in arts, vocational training related to professions in culture, and special teaching (plastic art and design, music, dance and dramatic arts) compared to the total number of students in non-university education (except infant education)	Academic years 2005-2006 and 2009-2010	INE and MECD
	F ₂ University education	Percentage of students taking university degrees related with art and culture compared to the university population	Academic years 2005-2006 and 2009-2010	INE and MECD
TECHNOLOGY AND INNOVATION	T ₁ Spending on R&D	ratio of domestic spending on R&D (thousand €) compared to staff working full time in R&D	2005-2006 and 2009-2010	INE and MECD
	T ₂ Patents	ratio of the number of applications for national patents compared to staff working full time in R&D	2005 and 2010	INE and OEPM
SOCIAL	S ₁ Immigrant population	Percentage of those born overseas	2005 and 2010	INE
	S ₂ Roma community	Estimation of the percentage of Roma community (2002 estimation) through the distribution of funding from the Roma Development Plan (2011)	2002	FSGG and MSPSI
LABOUR	L ₁ Employment in culture	Percentage of cultural employment out of total employment	2005 and 2010	INE and MECD
PUBLIC SPENDING ON CULTURE	G ₁ Public spending on culture	Settled per capita regional public spending on culture (€)	2005 and 2010	INE and MECD
SUPPLY OF CULTURE	C ₁ Supply of books and music	Total number of books and musical works (registered) per thousand inhabitants	2005 and 2010	INE and MECD
DEMAND FOR CULTURE	C ₂ Participation in artistic activities	Mean percentage of those who have engaged in artistic activities	2006-2007 and 2010-	MECD

			2011	
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Source: Authors' own

The values of the partial indicators and a statistical description thereof is provided in Table 2.

Table2. Description of partial indicators

	2005				2010			
	Average	Standard deviation	Max.	Min.	Average	Standard deviation	Max.	Min.
F₁ Non-university education	2.55	0.64	3.70	1.72	2.23	0.68	3.36	1.15
F₂ University education	9.97	4.47	18.02	0.00	9.97	4.97	21.90	0.00
T₁ Spending on R&D	53.54	7.42	65.85	40.15	62.33	9.43	77.16	42.39
T₂ Patents	2.02	0.78	3.46	1.04	1.72	0.56	3.25	0.98
S₁ Immigrant population	9.17	4.44	17.89	2.98	13.06	5.46	24.18	4.27
S₂ Roma community	1.49	0.97	3.49	0.00	1.41	0.92	3.19	0.00
L₁ Employment in culture	2.28	0.81	4.40	1.20	2.45	0.63	4.10	1.80
G₁ Public spending on culture	36.38	14.56	76.92	13.82	48.49	20.06	107.71	19.56
C₁ Supply of books and music	1.19	1.22	4.92	0.28	1.60	1.26	4.81	0.34
C₂ Participation in artistic activities	5.99	1.39	8.56	3.26	7.22	1.78	11.04	4.52

Source: Authors' own

a) Normalized Indicators

The first step in constructing the composite indicator was to normalise the partial indicators used. In this aspect, and due precisely to the endogeneity of the weights, one fundamental characteristic of DEA is invariance to changes in scale, with the same index being obtained for both the original and the normalised values. This means that any system of normalisation of the partial indicators which involves a change of scale in the variables (not in origin) would prove redundant in the model without additional restrictions. Nevertheless, this neutrality in the normalisation mechanisms is lost when further restrictions are added to the original model. Given that this was our case, we opted to normalise the partial indicators using the least aggressive system possible, in other words a transformation that would affect the final value of the synthetic indicator as little as possible. As a result, of the many existing mechanisms⁴, we opted for distance

⁴ For a detailed analysis of the various weighting systems, see: Freudenberg (2003); Jacobs, Smith and Goddard (2004).

to the reference unit (Parker 1991; Cherchye, Moesen and Van Puyenbroeck 2004; Murias, Miguel and Rodríguez, 2008). Said system normalise the indicators depending on their distance to a pre-determined reference point. In the present work, the mean value of the various autonomous communities was taken as the reference unit for each partial indicator.

Formal transformation is determined as follows:

$$I_{c,i} = Y_{c,i} / \bar{Y}_{c,i}$$

where $I_{c,i}$ represents the normalised value of the partial indicator i for autonomous community c ; $Y_{c,i}$ is the absolute value of the partial indicator i for autonomous community c , and $\bar{Y}_{c,i}$ represents the reference unit; the average of the partial indicator weights i for all the autonomous communities considered.

It should be pointed out that with this transformation, since it is a question of proportionality, the indicators obtained will be adimensional such that the resulting index, when calculated as an aggregate of said indicators, will also be so.

b) Weighting procedures:

One problem when constructing the composite indexes (indexes or composite indicators) is the weighting procedures or allocation of weights to the various sub-indexes that make up the indicator. It is precisely at this stage where researcher subjectivity is most in evident, since the choice of one method or another affects the final outcome (Saisana and Tarantola, 2002). In this regard, when compared to other weighting systems, DEA has the advantage that it determines weights endogenously, allowing individual selection of weights for each unit.

This endogenous nature of the weights endows the system with enormous flexibility (Cherchye et al., 2007) which, on certain occasions, may be deemed excessive. In such instances, it is possible to limit the flexibility when allocating weights by introducing additional restrictions on the absolute or relative values of the weights⁵.

In order to prevent DEA's excessive flexibility from allocating all the weight to the partial indicators which behaved best in each autonomous community and thus leaving the weight of the remaining ones null, we included absolute restrictions on the weights with regard to the original model. Specifically, we considered that the value range of the weights should be between 0.05 and 0.4. By doing this, we sought to ensure that all the indicators were considered and that none carried too much weight.

⁵ Many works include restrictions on the ranges within which the weights of the indicators must move. For instance: Allen et al., (1997); Sarrico and Dyson (2004); Murias, Martínez and Miguel, (2006); Murias, Miguel and Rodríguez (2008).

3. Results and analysis

In this section, we present and analyse the results obtained by applying the model to the available data. Firstly, in order to obtain a reference framework to test the results obtained when applying endogenous weightings, we designed a composite index with identical weights for all the partial indicators considered. In the following sections, we first analyse the composite index with identical weights, and then the results obtained based on the model which attaches endogenous weights to the indicators.

3.1. Composite Index with equal Weighting

The composite index for each of the regions was obtained as the weighted sum of the ten partial indicators considered, establishing an identical weight for each. Since for some dimensions (training component; technological and innovation component; social component; cultural component) we use two indicators, and for others only one (labour, institutional component), the former will have a greater relative importance in the composite index than the latter.

Table 3 shows the classification of autonomous communities based on the identical weights of the indicators and their position in the index of creativity ranking for 2005 and 2010. The last column reflects the gains and losses of position in the ranking between the two years. Graph 1 shows the ranking of the autonomous communities in terms of the value of the index for 2010 from highest to lowest, as well as the value obtained for 2005.

Table 3. Analysis of ranks 2005-2010. Equal weights

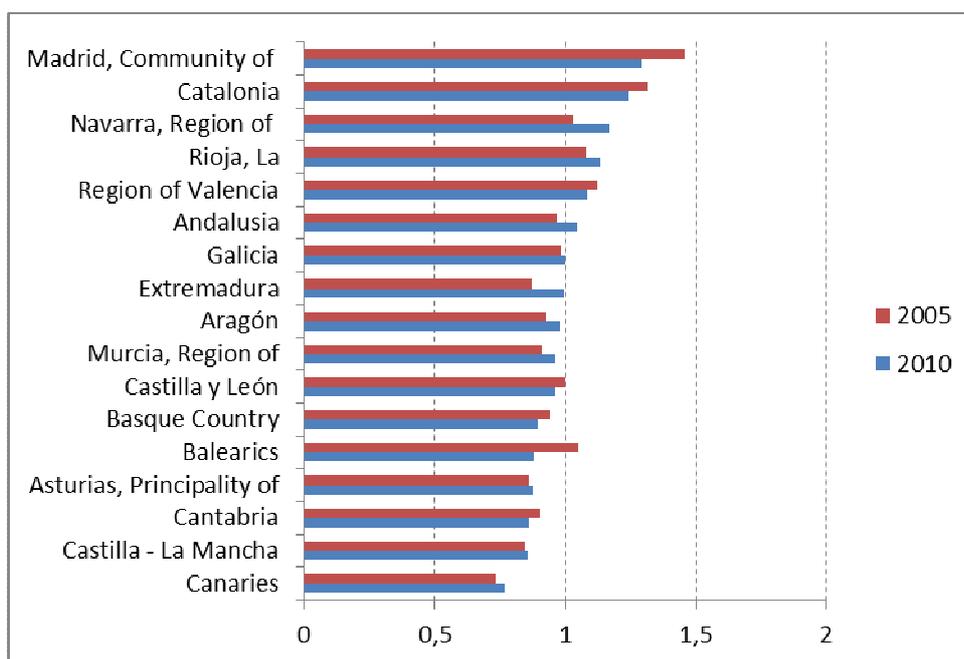
	RANK		Change in rank
	2005	2010	
Andalusia	9	6	3
Aragón	11	9	2
Asturias, Principality of	15	14	1
Balearics	5	13	-8
Canaries	17	17	0
Cantabria	13	15	-2
Castilla y León	7	11	-4
Castilla - La Mancha	16	16	0
Catalonia	2	2	0
Region of Valencia	3	5	-2
Extremadura	14	8	6
Galicia	8	7	1
Madrid, Community of	1	1	0
Murcia, Region of	12	10	2

Navarra, Region of	6	3	3
Basque Country	10	12	-2
Rioja, La	4	4	0

Source: Authors' own

Madrid and Catalonia achieve the greatest weights in the index in both years. A second group of autonomous communities, Valencia and La Rioja, alternate in the following positions. Bringing up the rear in both years are the Canaries and Castilla-La Mancha. Extremadura, Navarra and Andalusia made the biggest gains in the ranking, while Castilla y León and, particularly, the Balearics suffer the sharpest drop in the ranking of the autonomous communities.

Graph 1 Indexes of equal weighting



Source: Authors' own

3.2. Composite Index of endogenous weightings

Shown in Table 4 are the results of the composite index obtained with the endogenous weightings, following the method described in section two. The autonomous communities whose index takes the value 1 are the ones which evidence the highest creativity taking account of the dimensions considered. Lower index weights correspond to regions displaying lower levels of creativity.

In 2005, the group of autonomous communities with the highest indexes are Aragón, the Balearics, Catalonia, Madrid, Murcia and Navarra. The lowest index weights are found for Asturias and the Canaries. In 2010, this group of regions continues to head the ranking (except for the Balearics), and is joined by the autonomous communities of Extremadura, La Rioja, the Region of Valencia and Galicia. The “least creative” regions in this year are the Canaries and Castilla-la Mancha.

Based on these data, we are able to identify four different groups depending on the behaviour of the index. A first group is composed of regions displaying the highest indicator of creativity, namely, Aragón, Catalonia, Madrid, Murcia and Navarra. A second group comprises autonomous communities that evidence an improvement in the index of creativity between the two years and reach the maximum level in 2010, as is the case of Extremadura, la Rioja, the Region of Valencia and Galicia. The regions of Andalusia, Castilla y León, Asturias, the Basque Country and the Canaries make up a third group of regions where the value of the index increases in 2010 although without reaching the maximum. Finally, the fourth group comprises the autonomous communities whose indicator in creativity drops in 2010 compared to the value obtained in 2005. These are the regions of Cantabria, the Balearics and Castilla-la Mancha.

Table 4. Composite index values. Spain 2005-2010. Endogenous weights

	Composite index value		RANK		Change in Rank
	2005	2010	2005	2010	
Andalusia	0.8807	0.9991	14	10	4
Aragon	1	1	1	1	0
Asturias	0.8125	0.9304	16	13	3
Balearic Islands	1	0.8765	1	14	-13
Canary Islands	0.6594	0.8371	17	16	1
Cantabria	0.9674	0.9573	9	12	-3
Castile and Leon	0.943	0.9684	12	11	1
Castile - La Mancha	0.9444	0.8293	11	17	-6
Catalonia	1	1	1	1	0
Region of Valencia	0.957	1	10	1	9
Extremadura	0.984	1	7	1	6
Galicia	0.9319	1	13	1	12
Region of Madrid	1	1	1	1	0
Region of Murcia	1	1	1	1	0
Navarre	1	1	1	1	0
Basque Country	0.8239	0.8569	15	15	0
La Rioja	0.974	1	8	1	7

Source: Authors' own

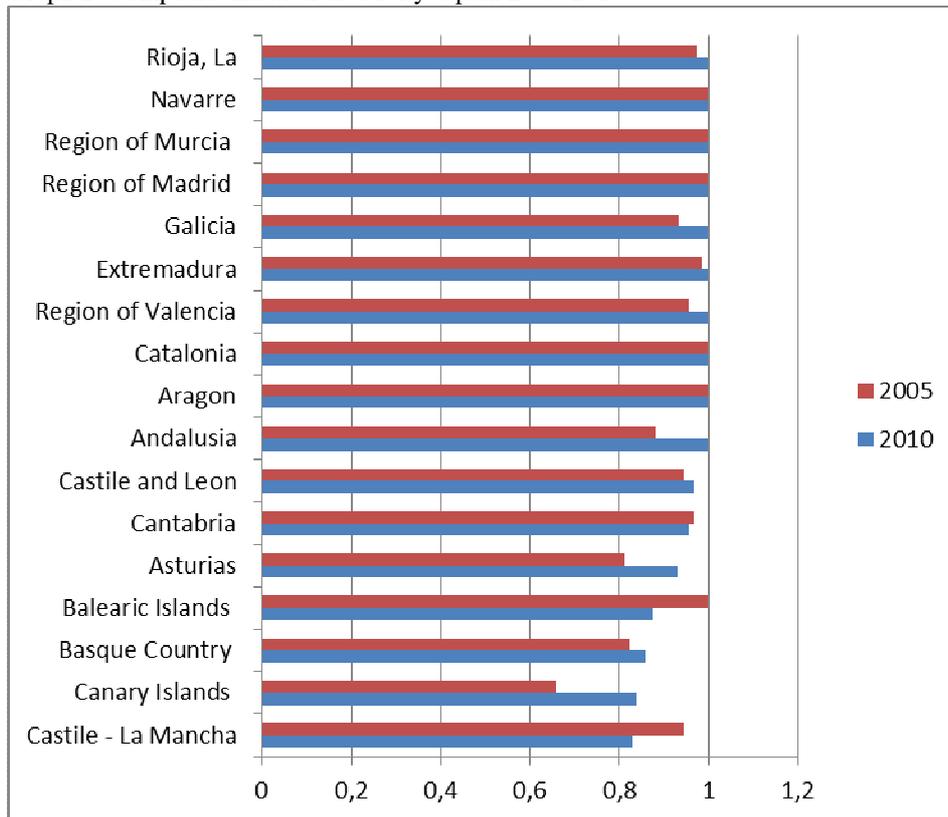
If we compare the weights of the composite index in the two years considered, it can be seen that most autonomous communities undergo an improvement, specifically 47%, whilst a drop is only apparent in three regions (18%). We also see that 35% of the autonomous communities maintain the value over the two years, and these are specifically the ones which achieve the highest creativity.

Particularly worthy of note are the cases of the Balearics and Galicia; the former due to the noticeable decline in its relative position. A look at the partial indicators reveals that this is due to a reduction in the relative contribution of the

T₂ indicator (patents). Conversely, Galicia climbs steeply in the ranking, and moves into the leading group of regions in 2010. In this case, the explanation may be found in the increased relative participation of indicator C₂ (involvement in cultural activities).

The relative position of the autonomous communities according to the value of the index in 2010 is shown in Graph 2.

Graph 2. Composite index of creativity. Spain 2005-2010



Source: Authors' own

Finally, we conducted a comparative analysis of the indexes calculated using both equal and endogenous weights. The results are shown in Table 5.

Table 5 Analysis of ranking, 2005-2010. Equal weights/endogenous weights

	Rankings						
	2005			2010			
	Equal weight	Endogenous weight	Difference in terms of the index	Equal weight	Endogenous weight	Difference in terms of the index	
Andalusia	9	14	5	6	10	4	Improves in the lower part
Aragón	11	1	-10	9	1	-8	Rises sharply
Asturias, Principality of	15	16	1	14	13	-1	Remains near the foot
Balearics	5	1	-4	13	14	1	Drops sharply, stable in both
Canaries	17	17	0	17	16	-1	Always last
Cantabria	13	9	-4	15	12	-3	In the lower half
Castilla y León	7	12	5	11	11	0	Stable near the foot
Castilla - La Mancha	16	11	-5	16	17	1	Remains near the foot
Catalonia	2	1	-1	2	1	-1	Remains at the top
Region of Valencia	3	10	7	5	1	-4	Climbs sharply
Extremadura	14	7	-7	8	1	-7	Climbs sharply
Galicia	8	13	5	7	1	-6	Climbs sharply
Region of Madrid	1	1	0	1	1	0	Always top
Region of Murcia	12	1	-11	10	1	-9	Climbs very sharply
Region of Navarra	6	1	-5	3	1	-2	At the top
Basque Country	10	15	5	12	15	3	Stable at the foot
La Rioja	4	8	4	4	1	-3	Climbs

Source: Authors' own

From the analysis of the data in Table 5, the following results emerge:

-There is a group of regions heading the ranking of creativity, with the highest weights in the two years considered and taking account of the two indexes: Madrid, Catalonia, Valencia, La Rioja, and Navarra. The results are similar to those reported in Martín, Palma and Martínez (2014) where these regions also evidenced the highest levels in the index of creativity.

-At the opposite end of the scale, the lowest positions are held by the Canaries, Castilla-La Mancha and Asturias, and there are slight changes in the relative order between them, taking into consideration the index and the year in question. As with the previous case, according to the index put forward by Martín, Palma and Martínez (2014) these autonomous communities are also the least “creative” in terms of the components analysed.

- The remaining regions are situated in intermediate positions, and a substantial difference can be seen in their relative positions depending on the reference years and indicator considered.

- Broadly speaking, when considering the endogenous weights the relative positions of the regions improves compared to the identical weightings. The reason underlying this is that the method applied leads to weighting to a greater extent those components which display a better behaviour in each autonomous community independently. Thus, particularly prominent are the regions of Aragón and Murcia which, after being near the foot when considering the index with identical weights, achieve the maximum value in the case of endogenous weightings. In the case of Aragón, the programme attaches particular weight to indicator T_2 (Patents), whereas in Murcia it does so for indicator S_2 (Roma community).
- Also worthy of note is the relatively low position of the Basque Country. Once again, indicator S_2 (Roma community) accounts for this result, since it has null value in this autonomous community.

4. Conclusions

In the present work, we construct a composite indicator of creativity using Data Envelopment Analysis (DEA). The value of the indicator is given by the weighted sum of the partial indicators corresponding to six areas or components of creativity, in line with the KEA index: training, technology and innovation, social diversity, labour, institutional and cultural. One of the most controversial aspects when constructing composite indicators is the allocation of weights to the various partial indicators. We applied the DEA method, since it allows endogenous allocation of the weightings, allocating the greatest weight to the component which behaves best in each autonomous community. The over-flexibility of the method and the chance that all the weight may fall on a single indicator has been restricted by introducing absolute restrictions on the weights in two senses; first, all the areas must be taken into account in the synthetic index and, second, none must carry too great a weight in the total. The analysis was carried out considering identical weights for all the indicators and autonomous communities and endogenous weightings.

The results obtained with the index of endogenous weightings allows two major groups of autonomous communities to be distinguished: those which always head the ranking whatever the year, Aragón, Catalonia, Madrid, Murcia and Navarra and the rest, whose behaviour differs depending on the period. In turn, within this particular group, two sub-groups can also be distinguished: those which improve over the years considered, Extremadura, la Rioja, the Region of Valencia and Galicia (and which even reach the maximum in 2010), Andalusia, Castilla and León, Asturias, the Basque Country and the Canaries, and the regions where the index of creativity drops, Balearics, Cantabria and Castilla-La Mancha.

Our findings concur with those of Martín, Palma and Martínez (2014) with regard to the most creative Spanish regions overall (Madrid, Catalonia, Valencia, La Rioja, and Navarra) and those which are least creative (Canaries, Castilla-La Mancha and Asturias)

The endogenous weighting technique enables us to identify those aspects in which the various autonomous communities display their greatest strengths and/or

weaknesses, since, whilst the former will evidence higher weights in the indicators, they will have less weight in the latter.

As a result, in 2005, the most important components in most of the regions were as follows: institutional component (indicator G1); technological and innovation component (specifically, indicator T2, patents), social diversity component (particularly, indicator S2, Roma community and, to a lesser degree, S1, immigrant population). The autonomous communities of Madrid and Catalonia are the only ones in which the provision of culture (indicator C3) evidences an important weight in said year. In addition, the education indicator “non-university education” emerges as important in La Rioja, Galicia and the region of Valencia.

At the opposite end of the scale, the labour component, training (with regard to indicator F2, university education) and spending on R&D are the ones which perform worst in all the autonomous communities with the minimum possible weights.

In 2010, social diversity (Roma community) and the institutional indicator continue to be the main strengths in most regions. Likewise, the cultural offer component gains ground and, together with Madrid and Catalonia, proves relevant in the autonomous communities of Galicia and Extremadura, as does the indicator of “non-university education”, which acquires importance in Andalusia, Asturias and Castilla-León.

Worth highlighting for 2010 is the fact that the labour component (indicator L1) becomes a relevant component, since it increases in weight in four autonomous communities, Asturias, Catalonia, Galicia and Castilla-León. In general, in 2010 there is greater heterogeneity in the dimensions that make up the main strengths in the various regions.

The paper contributes to the empirical literature addressing indexes of creativity in Spain which, although arousing increasing interest, continues to remain scarce. The paper also aims to provide deeper insights into the creative component from a standpoint which is comprehensive, yet which focuses on the cultural element.

In the present work, we compare the positions of the autonomous communities with regard to the index of creativity using identical weightings and endogenous weightings in the partial indicators. Our results show that the dimensions in which the regions evidence the greatest strengths and weaknesses differ, such that applying the same policies would not be recommendable.

Broadly speaking, indexes of creativity are an important instrument in economic policy, although it should be borne in mind that results differ depending on the dimensions considered and the chosen system of aggregation and weightings. When choosing the construction of an index using an endogenous weighting technique, we have attempted to remove part of the researchers’ subjectivity.

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