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ESTUDIOS / *RESEARCH STUDIES*

Bibliometric indicators for the analysis of the research performance of a multidisciplinary institution: the CSIC

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Abstract: An overview is provided of CSIC's research performance in the context of Spain, through a study of its scholarly production in the Web of Science database, complemented with ICYT and ISOC, during the period 2004-2009. The eight scientific and technical areas in which CSIC's centers are organised differ as to their national or international research orientation, their basic or applied nature, the degree of their collaboration and the size of their research teams; all of which influences each area's publication and citation practices as well as its WoS-based productivity. The specific features of the different areas must be thoroughly understood in order to expound on and interpret properly the results of studies dealing with research evaluation.

Keywords: Bibliometric indicators, Spanish National Research Council (CSIC), research evaluation, scientific areas, institutional assessment, Web of Science (WoS).

Indicadores bibliométricos para el análisis de la actividad de una institución multidisciplinar: el CSIC

Resumen: *Este artículo ofrece una visión general de la actividad investigadora del CSIC en el contexto de España a través del estudio de su producción científica en la base de datos Web of Science, complementada con ICYT e ISOC, durante el período 2004-2009. Las ocho áreas científico-técnicas en las que se organizan los centros del CSIC difieren en la orientación nacional o internacional de su investigación, su carácter básico o aplicado, la incidencia de la colaboración, y el tamaño de los grupos de investigación; todo lo cual influye sobre las prácticas de publicación y citación imperantes en cada área, y sobre su productividad derivada de WoS. Se señala la importancia de conocer las especificidades de las distintas áreas para plantear e interpretar adecuadamente los resultados de los estudios de evaluación de la actividad científica.*

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Palabras clave: *Indicadores bibliométricos, Consejo Superior de Investigaciones Científicas (CSIC), evaluación científica, áreas científicas, análisis institucional, Web of Science (WoS).*

1. Introduction

The ever increasing cost of research and the limited amount of economic resources that may be allocated thereto have promoted the implementation of research assessment practices in the more developed countries in the course of the last decades. In this context, bibliometric indicators play an essential role, since they complement peer review, supporting their decision-making process and providing objectivity to the evaluations. Nowadays, most science and technology reports include a bibliometric-based section which provides interesting data for the analysis of research in countries or regions. It contributes to describe the thematic profile of research units, identify its strengths, analyse their collaboration practices and study trends over time (see, for example, National Science Board 2010, OST 2010). Nevertheless, bibliometric analyses are not only applied at the macro level (countries), but they can also be used to study smaller units, such as disciplines or centres (meso level), or even research teams (micro level). Their use at institutional level is especially relevant, because institutions can monitor their activity through these indicators and complete their evaluations with additional information about both inputs and outputs —besides scientific publications—, which allow for the analysis of the scientific endeavour in its different dimensions.

This article analyses the scientific activity of the Spanish National Research Council (CSIC), which is Spain's main public research body. This institution, which is established nationwide, conducts research in all fields of knowledge and encompasses both basic research and the most advanced technological developments. CSIC is made up of 7 centres and 128 institutes —77 CSIC-only centres and 51 joint centres—, it is organised in eight major scientific-technical areas with a workforce of 13,500 employees —4,000 (30%) of which are researchers—, and it manages an annual budget of EUR 858.7 Million (CSIC, 2010).

The CSIC has undergone different reforms in its lifetime. In 2007, it became a State Agency attached to the Ministry of Science and Innovation. The aim of this change was to make its management more flexible and facilitate the accomplishment of its objectives, namely, to promote and conduct scientific and technological research, and to contribute and improve the economic, social and cultural development of Spain. In this way, the development of four-year action plans and the implementation of an «evaluation culture» in its centres have been key measures introduced in the management of the institution.

In recent years, the research activity of the CSIC has been analysed in numerous studies describing its scientific and technological results from different viewpoints. From a bibliometric perspective, mention is worth making of the annual reports prepared by the ACUTE group, in which the scientific production of the CSIC in international and Spanish databases is analysed (see for example, Gómez et al., 2010). Also of note is the study based on National Science Indicators (NSI) (Bordons and González-Albo, 2008), and various articles that analyse specific aspects of CSIC's research activity, such as scientific collaboration (De Filippo et al., 2008), micro-level scientific activity in certain areas (Costas et al., 2010a; Costas et al., 2010b), gender studies (Mauleon et al., 2008) or the analysis of technological production through patents (Romero de Pablos and Azagra Caro, 2009). Moreover, CSIC reports prepared by the Central Organisation of the Spanish National Research Council including statistical data about research facilities, material, economic and human resources, as well as aggregate data about scientific and technological results (see for example CSIC, 2010) also deserve mentioning.

The scientific production of CSIC's counterpart agencies in other European countries have also been the subject of several studies in the literature, such as those on the Italian CNR (Bonaccosi and Daraio, 2003; Tuzi, 2005) or the French CNRS (Jensen et al., 2009),

2. Objectives

The objective of this article is twofold: *a*) to provide a general overview of CSIC's research activity in its national context over the 2004-2009 period through the analysis of its research production in the Web of Science, complemented with the ICYT and ISOC databases; and *b*) to show differences in the performance of scientists by area with regard to their publication and citation practices, relying on the foregoing analysis and including a number of data from the Reports of the institution. The organisation of CSIC centres in eight scientific-technical areas provides a unique framework for studying the specific features of each area, an in-depth knowledge of which is required to adopt a correct approach for the development of studies on the evaluation of research performance.

3. Methodology

3. 1. Sources of data

In this study, we have carried out an analysis of CSIC's scientific production included in the Web of Science (WoS) multidisciplinary database, complemented with the national ICYT and ISOC databases. Some data about human and funding resources, as well as other CSIC research results included in CSIC's Annual Report 2006 (half-way point in our reference period) (CSIC, 2007) have also been considered.

The Web of Science database, produced by Thomson Reuters, includes more than 10,000 international journals, mostly published in English. This database has a better coverage of research of international interest rather than that of a more local or national scope, and therefore, basic research is more adequately covered than applied research. Moreover, it includes mainly original articles under the assumption that this is the principal means for the dissemination of knowledge. Despite its biases (see for example, Archambault et al., 2006), it allows users to gain a reliable insight of the scientific production of countries with a more international dimension obtaining both activity and impact indicators.

The documents published by the CSIC were extracted from the Spanish production, downloaded from the web (February 2010) with the search strategy «Spain» in the *address* field, and the different years from 2004 through to 2009 in the *year of publication* field. To this end, documents signed by the CSIC and/or its institutes were identified by means of a semi-automatic codification system that assigns an alpha-numerical code to each institution. All types of documents were downloaded but, in some analyses, only results based on «citable items» (referred to as 'articles' for the purposes herein) are shown, which include original articles, proceedings papers, notes and reviews[1].

3.2. Bibliometric indicators

Bibliometric studies generally take into account the use of different absolute and relative indicators in order to obtain complementary information about different aspects of scientific production (Van Raan, 2004). In this article, absolute indicators of activity and impact are used, and relative indicators are shown to compare CSIC's research activity against overall national research in different areas or disciplines.

a) Activity indicators

The research activity of CSIC centres and areas is quantified by means of the number of publications included in the WoS during the period of analysis. The production is distributed by disciplines according to the classification of journals into subject categories followed by WoS. Subject categories are aggregated into areas. The activity index (AI) of CSIC in a subject category or area is the quotient between the percentage of documents that the institution publishes in a given category or area and the percentage of total national publications in such category or area. Values above one indicate the specialisation of the CSIC in the corresponding category or area as compared to overall national output in such category or area.

b) Impact indicators

The *expected impact indicators* are based on the Impact Factor of journals, which is an indicator of the scientific prestige of journals (Garfield, 2005). The

[1] The label «proceedings papers» was included in 2008 to designate those articles previously presented as a conference. Before 2008 these documents were considered «articles». Since March 2001, these documents receive both labels: «article» and «proceedings paper».

average Impact Factor (IF) of the scientific output in each subject category and the percentage of articles published in journals in the first quartile (Q1) (in the list of journals in decreasing order by impact factor) are calculated (JCR, 2006).

The *observed impact indicators* are based on the analysis of the citations received by the documents. The use of citations as an indicator of research impact is based on the assumption that the citation of a document represents recognition of its interest and usefulness to build new knowledge. Moreover, a positive correlation between peer judgements and different citation-based indicators has been described elsewhere (see for example, Rinia et al. 1998). Although citation-based indicators have certain limitations widely described in the literature (see for example Garfield, 2005; Moed, 2005), its use is currently accepted as indicators of the influence of a given piece of research across the scientific community. In this study, a variable citation window has been used, i. e., the citations are counted from the year of publication of the article until the date of download (February 2010). The average number of citations by document and the percentage of non-cited documents are the indicators retained.

The following relative indicators have been calculated:

- Relative Impact Factor (RIF), that compares the average CSIC Impact Factor in a subject category or area with the average Impact Factor for overall national figures in the same category or area.
- Relative Citation Rate (RCR), calculated as the quotient between the average number of citations per CSIC document and the corresponding value for overall national figures in a given subject category or area.
- Non-Citation Relative Rate, calculated as the quotient between the percentage of non-cited CSIC documents and the corresponding percentage for overall national figures in a subject category or area.

c) Level of research

The basic or applied nature of research is analysed by means of the «research level» of journals (originally described by CHI Research Inc., see Noma, 1986, updated in 2007), which shows values between 1 (more applied areas) and 4 (more basic areas). This level has been calculated for journals included in the Science Citation Index (SCI) as well as for those fully covered in the Social Sciences Citation Index (SSCI), but not for those included in the Arts & Humanities Citation Index (AHCI).

d) Scientific Collaboration

Scientific collaboration is analysed in terms of the average number of authors per document, the average number of centres per document, and collaboration rates, which quantify the collaboration between authors and centres, and describe its national and/or international scope.

3.3. Other methodological aspects

An interesting advantage of the databases used in this survey is that they include the address of all the authors of the documents. However, since this information is not normalised, a semi-automatic codification of Spanish centres was carried out as an essential task to be performed prior to the calculation of bibliometric indicators.

The thematic delimitation used in this study is based on the classification of journals in subfields or subject categories (WoS categories) established by Thomson Reuters (2010 edition) where each journal may even be assigned to six different categories. These categories are grouped in ten subject areas that are shown in the results section.

The results have been calculated using the total count system, according to which each document is wholly assigned to all the centres included in the document. In the «Productivity» section, the scientific output of each scientific area has also been calculated on a fractional count basis in order to explore the possible differences between both counting systems. Under the fractional count system each institute receives fractional credit on the basis of the proportion of its participating centres. Thus, if a document is signed by, for example, three centres, two CSIC centres and one university centre, we have assigned 2/3 (0.66) to CSIC and 1/3 (0.33) to the university.

This article is structured as follows. Firstly, general data about the scientific performance of the CSIC are shown, including activity and impact indicators in each of the ten WoS areas and its comparison with the average performance results for Spain. Secondly, differences in the publishing and citation practices of the CSIC's eight scientific-technical areas are presented. Finally, a research activity profile for each CSIC area is defined. Such profiles can be used as reference for the analysis of the performance of the different centres and institutes included in each area.

4. Results

4.1. The CSIC: a general overview

Over the 2004-2009 period, the scientific production of the CSIC included in the Web of Science amounts to 44,733 documents (41,571 articles), representing 17% of the Spanish output in this database. The CSIC is the third institutional sector in terms of production in Spain, after University (60% of documents) and the Health Care Sector (26%) (Gómez et al., 2010).

The CSIC is an ensemble of different kinds of centres that include CSIC-only centres (67% of documents), joint centres —mainly with University centres— (31%) and associated units (7%). Likewise, the CSIC participates in different corporations (such as the Institute of Space Studies in Catalonia through the Institute of Space Sciences) that account for 3% of CSIC's publications.

The geographic distribution of the documents shows certain concentration in some regions, especially in Madrid (42%), where a large number of CSIC centres are located. However, some regions obtain high relative activity rates with a small number of centres (for example, the regions of Aragón and the Balearic Islands).

CSIC's collaboration rate was found to be higher than the Spanish average (76% vs. 66%), but the most striking issue is its high international collaboration rate (47% of its documents include at least one foreign centre, versus 37% for the overall Spanish output). However, since international collaboration varies by field, it is more appropriate to analyse it by subject areas (see section 4.2).

In order to obtain a general overview of CSIC's activity in the national context, Table I shows its production by WoS areas (based on the aggregation of subject categories) with a series of absolute and relative indicators about activity and visibility. Table I includes CSIC's activity (column A), overall Spanish activity (column B), and finally, relative indicators describing CSIC's activity in relation with the average profile for the country (column C).

Concerning CSIC's scientific activity, the greatest number of articles is published in Physics (29%). Agriculture/Biology/Environment (28%), Biomedicine (22%) and Chemistry (22%), where the CSIC shows certain specialisation since the percentage of articles produced in each of these areas is higher than the corresponding percentage of overall national output (AI > 1). On the contrary, the CSIC shows poor specialisation or relative activity in Mathematics, Social Sciences and Clinical Medicine. It is interesting to note that CSIC production represents nearly 30% of Spanish document output in Agriculture/Biology/Environment and Physics, but its contribution to other areas such as Clinical Medicine, Social Sciences and Mathematics is lower than 6% (see % CSIC contribution in table I).

In order to assess the quality of research developed at the CSIC, the focus is put on the prestige of the publication journals (through the Impact Factor) and the impact of its documents (through the received citations). On average, the CSIC publishes in higher impact factor journals when compared to overall national output in all subject areas (RIF equal or higher than 1), the values obtained for Multidisciplinary (RIF = 1.78), Mathematics (RIF = 1.58), Social Sciences (RIF = 1.37) and Engineering/Technology (RIF = 1.32) being especially remarkable. The CSIC publishes 60% of its articles in journals with a high impact factor (first quartile of each discipline) while the corresponding percentage for the overall national output is 45%.

Regarding received citations, the CSIC obtains an average citation rate per article equal or higher than that of the overall national output in every subject area, with the exception of Humanities. The advantage of the CSIC is especially significant in Mathematics, Social Sciences (although the CSIC has a low relative activity in this area) and Multidisciplinary (RCR > 1.5).

The percentage of CSIC's articles without citations ranges from 84% in Humanities to 14% in Multidisciplinary. The CSIC obtains lower non-citation rates than overall national output in all subject areas. CSIC's low percentage of non-cited articles in Multidisciplinary journals is worth noting when compared to the value for Spain as a whole (14% vs. 29%), although its absolute number of

TABLE I

Activity and impact of CSIC by WoS areas; absolute and relative indicators (articles) (WoS 2004-2009)

WoS Areas	CSIC (A)							Spain (B)							Relative indicators CSIC/Spain (C)				
	No. art.	% art.	IF 2006	No. citations art.	% Non-cited articles	% Q1 art.	Level	No art.	% art.	IF 2006	No. citations art.	% Non-cited articles	% Q1 art.	Level	AI	RIF	RCR	Relative Non-citation rate	% CSIC contrib.
Agric., Biol., Environment	11,581	27.86	2.170	6.78	21.56	58.01	3.08	38,628	18.40	1.936	5.57	26.18	51.96	2.92	1.51	1.12	1.22	0.82	29.98
Biomedicine	9,331	22.45	4.179	10.00	15.76	61.27	3.67	42,658	20.32	3.494	8.51	19.23	50.39	3.30	1.10	1.20	1.18	0.82	21.87
Social Sciences	767	1.85	1.671	5.11	34.81	53.19	2.78	13,835	6.59	1.218	2.67	48.87	23.27	1.97	0.28	1.37	1.91	0.71	5.54
Physics	12,225	29.41	3.063	9.11	20.81	66.21	3.61	37,315	17.78	2.730	7.34	23.32	61.76	3.55	1.65	1.12	1.24	0.89	32.76
Humanities	413	0.99	—	0.49	83.78	—	—	3,879	1.85	—	0.51	85.72	—	—	0.54	—	0.96	0.98	10.65
Engineering, Technology	7,747	18.64	2.160	5.71	26.84	62.36	2.55	43,045	20.51	1.635	4.27	33.74	47.31	2.28	0.91	1.32	1.34	0.80	18.00
Mathematics	384	0.92	1.329	5.20	33.85	49.74	3.10	11,593	5.52	0.842	2.74	39.94	29.53	3.02	0.17	1.58	1.90	0.85	3.31
Clinical Medicine	2,560	6.16	3.684	8.90	19.14	62.62	2.65	43,833	20.88	2.979	7.66	28.25	39.06	2.10	0.30	1.24	1.16	0.68	5.84
Multidisciplinary	468	1.13	13.885	28.91	14.10	85.04	3.70	1,939	0.92	7.822	18.64	29.40	53.27	3.39	1.23	1.77	1.55	0.48	24.14
Chemistry	8,984	21.61	3.226	7.97	18.59	66.81	3.41	33,264	15.85	2.977	7.73	19.03	62.76	3.38	1.36	1.08	1.03	0.98	27.01

Note: percentage of articles by areas calculated with respect to the total real number of articles. The sum is higher than the real total because documents may be assigned to more than one area due to the multi-assignation of journals into disciplines.

AI: Activity Index; RIF: Relative Impact Factor; RCR: Relative Citation Rate.

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documents is small. Likewise, it is interesting to observe the low percentage of CSIC's non-cited articles in Social Sciences and Clinical Medicine (14 and 9 percentage points below overall national values, respectively.

Publication in multidisciplinary journals is particularly meaningful, since these include prestigious journals such as *Nature* or *Science* which have a large audience and high rejection rates of original articles. The CSIC has published 142 articles in *Nature* or *Science* which represent 46% of Spanish articles in these journals while total CSIC production only represents 17% of the total Spanish articles in the WoS database. The fact that CSIC scientists are able to publish in these journals and receive a high number of citations tells us about the capacity of researchers to conduct high-quality research of international relevance in leading-edge fields.

On the whole, CSIC research is more basic than overall national output. This may be derived from the higher percentage of articles published in journals with a research level of 3 or 4 (83% for CSIC vs. 69% for Spain)[2]. These differences cannot be explained only by a different thematic profile of research (higher relative activity in more basic areas), since the CSIC tends to obtain a more basic research level than Spain as a whole in each of the areas shown in Table I.

4.2. CSIC: specific features of its scientific-technical areas

CSIC's centres are split across eight scientific-technical areas according to their research topics. CSIC areas accounting for the higher number of publications are: Biology and Biomedicine (20%), Physical Science and Technologies (18%); Materials Science and Technology (18%); and Natural Resources (16%). The areas with lowest production are Chemical Science and Technology (13%); Agricultural Sciences (8%); Food Science and Technology (6%) and Humanities and Social Sciences (3%) (table II).

Each CSIC area has its own characteristics with respect to the type of research developed, its organisation and kind of results. National or international scope of the research, its basic or applied nature, its propensity to collaborate —in particular, with foreign partners—, and the size of research teams are some of the features that vary among scientific fields, as explained below. All these differences support the convenience of studying CSIC areas separately, which proves also useful for research management purposes within the institution.

a) National/International scope

Researchers who work in areas with a high international orientation (experimental sciences, natural sciences) tend to publish in international journals which are better covered in WoS databases than more local-oriented journals. The case of Social Sciences, and especially Humanities, where researchers rely heavily

[2] «Journal with no level assigned —including all AHCI journals— are not considered here (26% of Spanish documents and 14% of CSIC ones)».

TABLE II

Number of documents in WoS, ICYT and ISOC databases by CSIC's scientific-technical areas (2004-2009)

Area Code	CSIC area	No. Institutes (2006)[1]	No. Doc. WoS	No. Doc. ICYT	No. Doc. ISOC	% Doc in Spanish journals and Spanish language (WoS)
1	Hum. Soc. Sciences	18	1,198	40	1,186	63.02
2	Biol. Biomedicine	20	8,737	131	5	0.80
3	Natur. Resources	19	7,350	889	145	3.01
4	Agricul. Sci.	12	3,535	397	20	0.42
5	Physic. Sci. Tech.	21	8,062	158	21	0.32
6	Material. Sci. Tech.	10	7,855	478	9	3.95
7	Food Sci. Tech.	5	2,521	244	8	2.82
8	Chem. Sci. Tech.	11	6,051	91	7	0.38
	Total	116	44,733	2,392	1,615	3.61

Note: the total production of each area is lower than the aggregation of the WoS, ICYT and ISOC columns because there is some overlap among databases. For guidance, it can be noted that 9% of the ISOC journals and 12% of the ICYT journals used by CSIC scientists for publication are also covered by WoS.

[1] Data from 2006 CSIC Report (CSIC 2007).

in national journals which are published in local languages and are not often included in WoS is worth noting. In this sense, our data show that the production of CSIC researchers in Hum. Soc. Sciences is equally distributed between the international WoS and the national ISOC databases, whereas in the rest of CSIC areas the contribution of the Spanish databases ISOC and ICYT is very limited. However, it is necessary to take into account that WoS coverage of so-called «regional journals» has improved in the past few years. Under this denomination, Thomson Reuters includes those journals with a more local scope mainly working in the Social Sciences and Humanities areas. Therefore, the exclusive contribution of ISOC will tend to dwindle in coming years.

On the other hand, the use of journals published in Spain and written in the Spanish language may also be considered in the WoS context as an indicator of the «national scope» of the research. In this respect, note that 63% of WoS publications of CSIC researchers in Hum. Soc. Sciences are locally-oriented against only 4% of documents in the whole CSIC (table II).

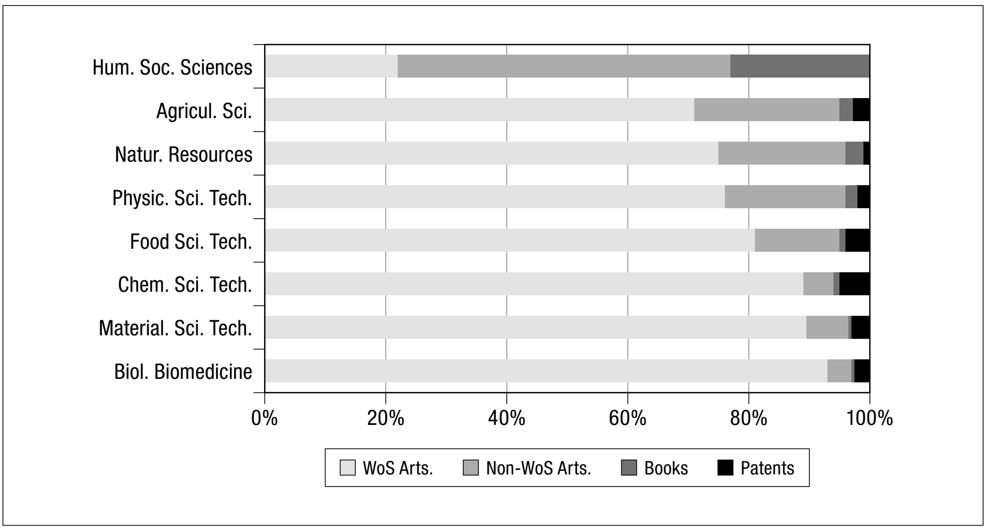
b) Dissemination of research

CSIC areas differ in the type of document more frequently used for the dissemination of research, as shown in Figure 1, based on 2006 CSIC Report. This section provides an analysis of the contribution of different kinds of output by areas (articles in WoS journals, non-WoS articles, books/monographs and patents). It should be pointed out that this analysis is only indicative because some types of outputs are not taken into account (technical reports, for example) and all kinds of contributions are equally considered, although books are frequently more heavily weighted than articles in studies dealing with the evaluation of research activity (see for example Aknes and Sivertsen, 2009).

Differences in the document type which predominates in each area are remarkable. Thus, articles in WoS journals, which are the main output used in this survey, represent around 90% of total production in Biol. Biomedicine; Chem. Sci. Tech.; Material. Sci. Tech.; and between 70% and 80% in Food Sci. Tech.; Physic. Sci. Tech.; Natur. Resources and Agricul. Sci. However, this type of document only represents a fraction above 20% of the production in the Hum. Soc. Sciences area where books, monographs and articles in non-WoS journals make up the lion's share of the production (22% and 56% respectively).

FIGURE 1

Scientific production of CSIC by scientific-technical areas according to 2006 CSIC Report



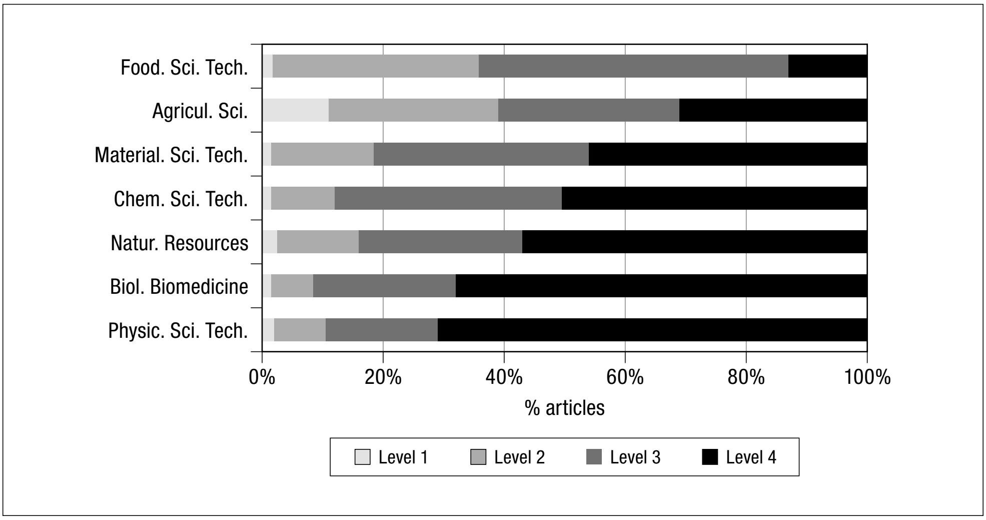
c) Basic/Applied nature of research

Research in Food Sci. Techn. and Agricul. Sci. shows a more applied-oriented nature than in the other CSIC areas if publication journals are considered. Thus, more than 35% of their articles are published in journals of level 1 or 2, whereas such rate is down to 20% for articles in Material. Sci. Tech. and to less than 10%

in Biol. Biomedicine. The most basic-oriented areas are Biol. Biomedicine, Physic. Sci. Tech. and Chem. Sci. Tech., where nearly 90% of documents are published in journals of levels 3 or 4 (figure 2).

FIGURE 2

Research level of CSIC scientific production by scientific-technical areas (WoS 2004-2009)



Note: Hum. Social Sciences area not shown because most of AHCI journals and many SSCI journals do not have research level assigned.

d) Scientific collaboration

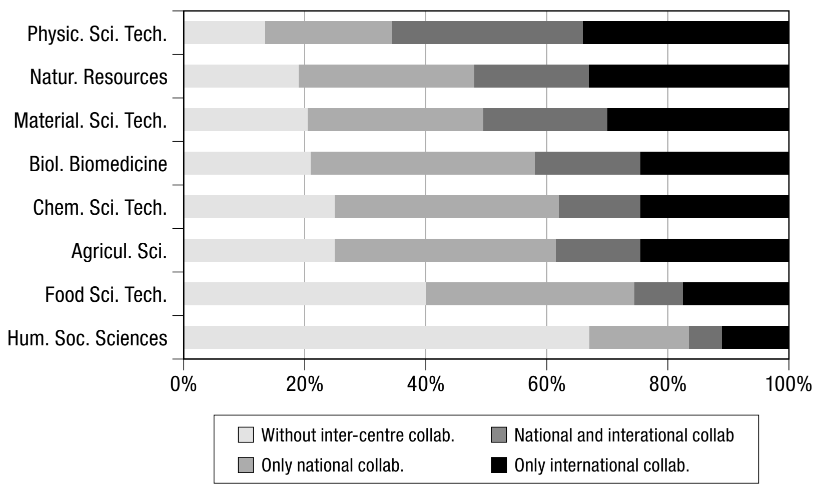
There are substantial differences between areas as regards the propensity of their researchers to collaborate, as well as in the predominating type of collaboration in each case (figure 3). In as far as collaboration among centres is concerned, Hum. Soc. Sciences shows the lowest collaboration rate (66% of its documents are signed by a single institution —«without collaboration» in figure 3—), whereas Physic. Sci. Tech. is ranked at the other end of the scale with 86% of its documents signed by at least two centres.

The national collaboration rate ranges from 22% in Hum. Soc. Sciences to 55% in Biol. Biomedicine. With respect to international collaboration, the highest values are found in the Physic. Scie. Tech., where 65% of documents have been prepared under this type of cooperation. Such a high rate, similar to the overall national rate in this area for Spain as a whole (Gómez et al., 2010), may be explained by the basic nature of research conducted in this area (Frame and Carpenter, 1979; Katz and Martin, 1997) and the presence of «big science». The lowest international collaboration rates are found in Hum. Soc. Sciences (16%)

and Food Sci. Techn. (25%), where research activity is much more circumscribed within national boundaries (Gómez et al., 1995).

FIGURE 3

Collaboration pattern of the CSIC by scientific-technical areas (WoS 2004-2009)



e) Size of research teams

The number of authors by document provides useful guidance information on the size of research teams in the different areas. Work conducted by individual scientists still predominates in Hum. Soc. Sciences, as attested by the fact that over 58% of documents in this area are single-authored, whereas documents written by more than 6 authors are almost non existent.

The average number of authors per document ranges from 2, in Hum. Soc. Sciences, to 54 in Physic. Sci. Tech. (table III). The last value is surprisingly high, but we should keep in mind that the average number of authors or centres per document can be strongly influenced by outliers, and in the area of Physic. Sci. Tech. there are some documents with more than 2,000 authors which have a significant impact on the average value. Therefore, it is also interesting to analyse the median of the distributions. The median for the number of authors per document is 4 or 5 authors across all areas, with the exception of Hum. Soc. Sciences, where it is 1 author/document. Regarding the number of centres per document, the median is also 1 in Hum. Soc. Sciences, albeit it ranges between 2 and 3 centres in all other areas.

TABLE III

Average number of authors and centres by CSIC's scientific-technical areas (WoS 2004-2009)

CSIC Area	No. Doc.	No. authors/doc. $\bar{X} \pm SD$ (med.)	No. centres/doc. $\bar{X} \pm SD$ (med.)
Hum. Soc. Sciences	1,198	2.07 ± 2.04 (1)	1.68 ± 1.59 (1)
Biol. Biomedicine	8,737	6.24 ± 6.29 (5)	3.09 ± 2.97 (3)
Natur. Resources	7,350	4.74 ± 3.72 (4)	2.92 ± 2.31 (2)
Agricul. Sci.	3,535	4.99 ± 2.53 (5)	2.50 ± 1.58 (2)
Physic. Sci. Tech.	8,062	54.43 ± 164 (5)	10.85 ± 22.93 (3)
Material. Sci. Tech.	7,855	5.16 ± 2.43 (5)	2.74 ± 1.54 (2)
Food Sci. Tech.	2,521	4.84 ± 5.46 (4)	2.22 ± 5.14 (2)
Chem. Sci. Tech.	6,051	5.23 ± 2.48 (5)	2.42 ± 1.40 (2)
Total	44,733	14.05 ± 72.20 (5)	4.16 ± 10.48 (2)

Note: data expressed as average±standard deviation (median).

f) Citations and Impact Factor

Inter-area differences in the citation performance of researchers can be observed in table IV. For each scientific-technical area, Table IV includes information on the number of articles (Narts), a series of expected impact indicators (average impact factor and percentage of articles published in first quartile journals) and a series of observed impact indicators (number of citation/article, percentage of non-cited articles and highly-cited papers). The label «highly-cited papers» (HCPs) refers to the top 1% of documents with the highest number of citations within each CSIC area.

Highest citation rates are observed in Biol. Biomedicine (11.4 citation/article), followed by Physic. Sci. Tech. (10.35 citations/article). These areas also obtain the highest average impact factor rates according to their publication journals. However, inter-area comparisons of impact rates are not appropriate because of different citation practices between areas. When HCPs are considered, the highest threshold (number of citations required in order to consider a document as a HCP) is also found in the abovementioned areas, since a paper needs at least 90 citations in Physic. Sci. Tech. and 85 in Biol. Biomedicine to be considered as a highly-cited paper. The Physic. Sci. Tech area shows other additional specific features: it has the largest concentration of citations within the core of its HCPs, since the most cited 79 papers concentrate 27% of the citations received by the articles in the area, showing, in addition, the highest extreme values (articles with more than 3,000 citations) (table IV). This performance is partly due to the strong international nature of research in Physics, a field where we observe a high rate of international collaboration, a high number of authors and institutions involved in a given research and, in many cases, research conducted in the framework of international laboratories («*big science*»).

The values obtained for the Hum. Soc. Sciences area have to be interpreted with caution, since we must keep in mind the lower reliability of indicators based in citations covered by WoS in these areas, especially in Humanities, to the point that Thomson Reuters does not calculate the «impact factor» on journals in said area. In fact, data on citations and impact in Hum. Soc. Sciences included in table IV are principally drawn from the Social Sciences area. On the other hand, almost all areas publish more than 50% of their articles in journals located in the first quartile of their disciplines, with the exception of Hum. Soc. Sciences, an area prone to publish in Spanish journals written in Spanish language (63%) which are not usually ranked in the first quartile.

Inter-area differences in citation rates are due to different factors such as the coverage of areas in WoS database, the ageing of the literature and the density of citations, which may vary from one to another area. The lesser reliability of citation-based indicators in Social Sciences, and especially in Humanities, is due to the slower rhythm of ageing of the literature in these disciplines, their lower rate of coverage by WoS (that includes mainly international journals, as well as some national journals, but no books), and the non-inclusion of citations from non-WoS material which constitutes an important means for the dissemination of research in the area (Moed, 2005).

TABLE IV

Impact indicators of CSIC's production by scientific-technical areas (WoS 2004-2009)

CSIC Area	No Art.	% Q1 Art.	Average IF	No. Citations/art.			HCP*		
				No citations/ art.	Min.-Max.	% Non-cited articles	HCP citation threshold	No Art.	% Area citations
Hum. Soc. Sciences	716	22.63	1.330	1.79	0-44	61.87	29	7	18.77
Biol. Biomedicine	7,547	65.77	4.994	11.37	0-535	15.18	85	75	13.62
Natur. Resources	6,957	52.95	2.317	6.88	0-459	21.89	52	71	14.99
Agricul. Sci.	3,347	52.08	2.029	6.35	0-128	23.04	50	34	11.69
Physic. Sci. Tech.	7,855	68.38	3.546	10.35	0-3,501	21.81	90	79	27.24
Material. Sci. Tech.	7,723	61.57	2.759	6.83	0-570	22.85	57	81	16.34
Food Sci. Tech.	2,441	60.71	2.134	6.48	0-215	21.55	42	24	10.17
Chem. Sci. Tech.	5,771	64.32	3.226	8.51	0-294	17.66	63	62	12.54

* 1% of more cited articles.

As a result from the foregoing, it is not advisable to compare areas using citation or impact-factor-based indicators, unless standardised indicators are used. However, these indicators are useful to portray the average performance of this area, which may be used as a benchmark for the comparison of the scientific activity of the different institutes involved. Nevertheless, a more precise study would require conducting an analysis by discipline.

g) *Productivity by area*

Table V shows for each CSIC's scientific-technical area the number of researchers, the economic budget in 2006 (including only national funding for research projects and «special actions») (source: 2006 CSIC Report) and the average annual production, calculated on a total and fractional count basis.

The use of a total or fractional count system does not affect all centres and areas in the same way. A fractional count approach reduces the production across almost all areas (by 50% on average) (table V). The smallest drop occurs in Hum. Soc. Sciences (–20%) where collaboration is very limited, whilst the biggest is found in Physic. Sci. Tech. (–59%), where the presence of various centres in a given document is very frequent (last column in table V).

A good correlation between the total and fractional count of the production of the different scientific-technical areas (figure 4*a*) and centres (figure 4*b*) is apparent. The most distant points from the regression lines refer to the area of Physic. Sci. Tech. (figure 4*a*) and to its centres (figure 4*b*), since they record the largest drop in their production under the fractional count system, due to the high collaboration rate in the area. In figure 4*b*, there is evidence that several Hum. Soc. Sciences and Food Sci. Techn. centres are above the regression line, because their low collaboration rates lead to a limited reduction of their production on a fractional count basis.

An approximation to the productivity of each CSIC area may be obtained by establishing a relationship between WoS production and the number of researchers or the economic resources invested in research. On a total count basis, Physic. Sci. Tech. is found to be the most productive area (4.27 doc/researcher and year), followed by Material. Sci. Tech. (3.62), Biol. Biomedicine (3.53) and Natur. Resources (3.4). The area recording the lowest productivity rate is Hum. Soc. Sciences (0.79). Using the fractional count system, inter-area differences in productivity are smaller, and Hum. Soc. Sciences and the more applied-oriented areas obtain the lowest values (Food Sci. Techn. and Agricul. Sci.) (figure 5).

The ratio between the economic budget for 2006 and scientific production (annual average) is shown in table V. This relationship between funding and WoS output is for guidance purposes only and does not provide an accurate measure of the cost of research since it only takes into account financial support granted on the basis of projects and other expenses, such as the cost of personnel, are not included. Differences among areas are identified, partly due to different needs

TABLE V

CSIC's scientific production and productivity of scientific-technical areas using total and fractional count systems

CSIC Areas	No. Institutes	No. Researchers[a] (2006)	Funding (×1,000€) (2006)	Total count (annual average)			Fractional count (annual average)			Fractional vs. total count reduction (%)
				No. Doc. WoS	Productivity	Euros/doc. (×1,000)	No. Doc. Wos	Productivity	Euros/doc. (×1,000)	
Hum. Soc. Sciences	18	253	7,939	199.67	0.79	39.76	160.632	0.63	49.42	–20%
Biol. Biomedicine	23	413	113,819	1,456.67	3.53	78.14	743.540	1.80	153.08	–49%
Natur Resources	21	360	50,182	1,225.00	3.40	40.96	620.933	1.72	80.82	–49%
Agricul. Sci.	12	292	33,359	589.17	2.02	56.62	334.437	1.15	99.75	–43%
Physic. Sci. Tech.	26	315	49,976	1,343.67	4.27	37.19	548.092	1.74	91.18	–59%
Material. Sci. Tech.	11	362	35,646	1,309.17	3.62	27.23	685.228	1.89	52.02	–48%
Food Sci. Tech.	7	186	19,257	420.17	2.26	45.83	277.195	1.49	69.47	–34%
Chem. Sci. Tech.	11	311	31,444	1,008.50	3.24	31.18	568.238	1.83	55.34	–44%
Total		2,492	341,622	7,455.50	2.99	45.82	3,626.88	1.46	94.19	–51%

[a] Number of researchers includes tenured staff. Non-tenured staff and grant-holders are excluded. Sources: 2006 CSIC Report.

FIGURE 4

Correlation between fractional and total count of scientific production by CSIC's scientific-technical areas (figure 4a) and CSIC's centres (figure 4b)

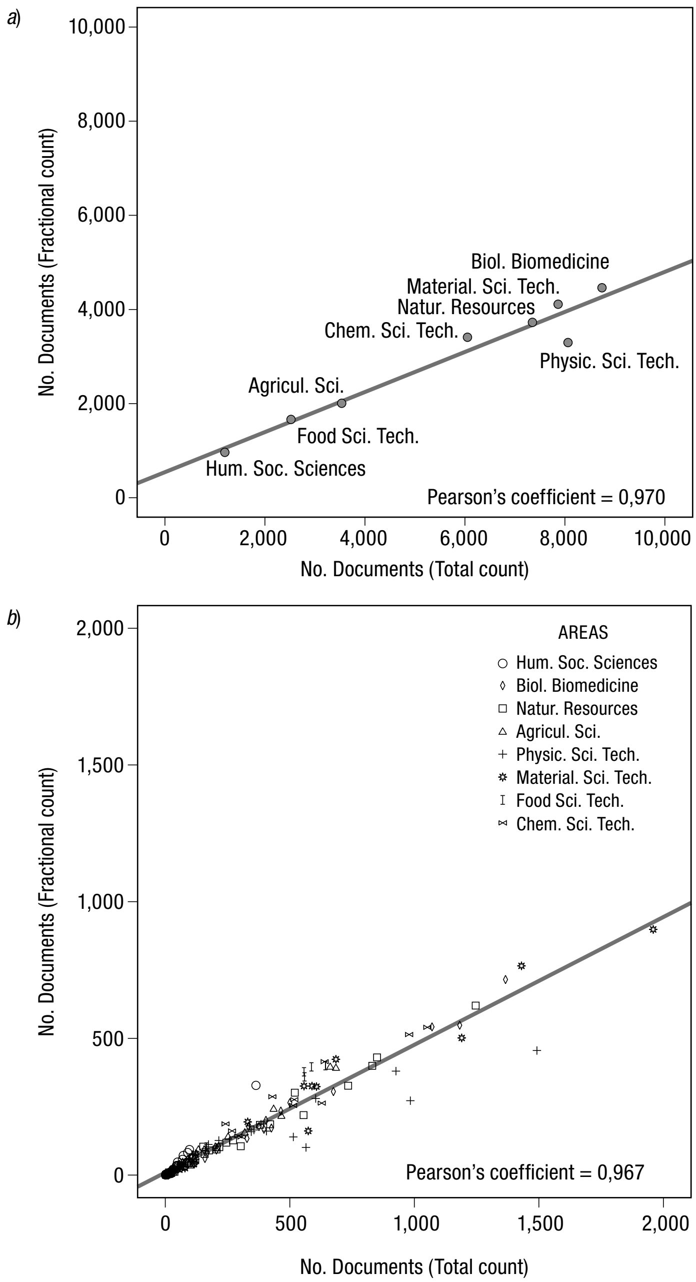


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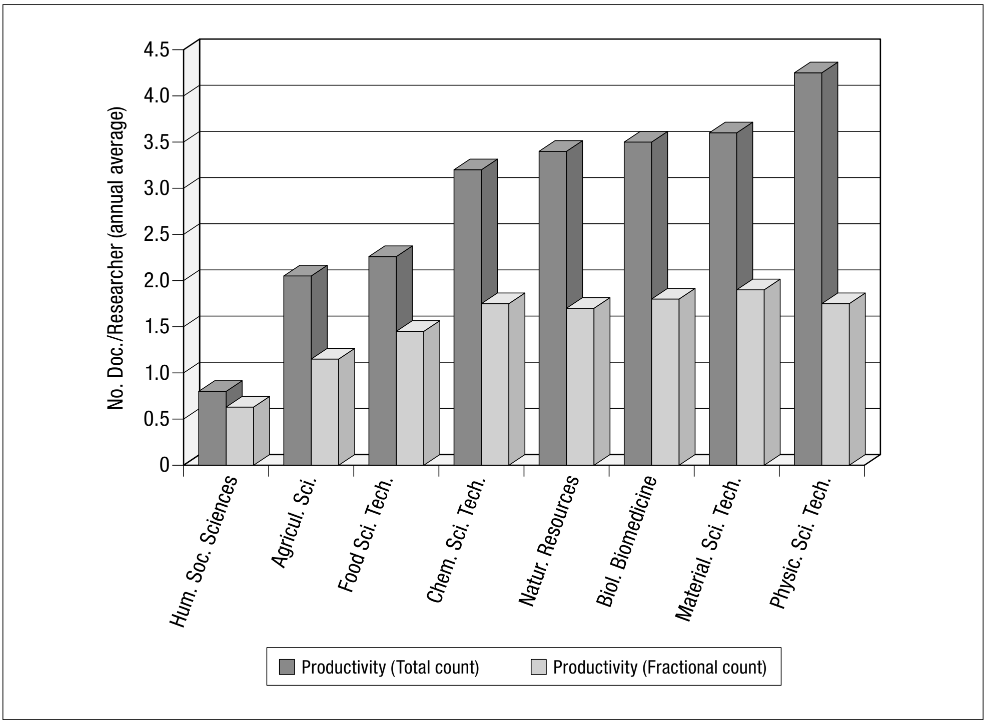
FIGURE 5

Average productivity of CSIC researchers by scientific-technical areas: total vs. fractional count (WoS 2004-2009)



in terms of equipment or infrastructures, which vary depending on the use of the total or the fractional count system.

5. Discussion and conclusions

This study shows the usefulness of bibliometric indicators to obtain a general overview of the research performance of a given institution and to identify its areas of specialisation and the impact of its research in different disciplines. Although the indicators used allow us to analyse the activity of specific centres and disciplines, this level of analysis is not included in this study because it exceeds the objectives of the present article and the results thereof are available in a detailed report (Gómez et al., 2010). The aim of this article is to provide a general overview of the activity of a multidisciplinary institution such as the CSIC, highlighting the special features of its different thematic areas, which should be known in order to design and interpret correctly the studies conducted for research evaluation purposes.

The CSIC: a global perspective

This study reveals the important role of the CSIC in the Spanish R&D system. With a workforce representing 6% of overall Spanish research staff (CSIC, 2009), the CSIC produces 17% of the country's scientific publications. The fact that CSIC scientists are entirely devoted to research and do not have teaching obligations, as is the case with university professors, contributes to explain its high research productivity. Accordingly, the average productivity of CSIC scientists observed in this study is higher than the one described in other works dealing with research performance conducted at universities (see, for example, Aksnes and Sivertsen, 2009).

CSIC's production is important not only from a quantitative point of view, but also from a qualitative one. Thus, CSIC researchers manage to get their documents published in more prestigious journals than the country's average in most areas —measured by the average impact factor and the percentage of documents in first quartile journals— and obtain higher impact rates as measured by the citations received by their publications. The high percentage of documents published by the institution in prestigious journals, such as *Nature* and *Science,* is another evidence of the capacity of CSIC scientists to carry out competitive research in leading-edge scientific fields.

In our study, the impact of CSIC's scientific production is compared against a national benchmark (the Spanish total production), but it is also interesting to take into account the international context. According to a prior work, the impact of CSIC's works reached world-average level in the mid '90s. Said level has been outperformed by more than 15% in recent years and CSIC's impact rates are above EU-27 average (Bordons and González-Albo, 2008). Furthermore, the percentage of CSIC documents that obtained citations with a 5-year citation window rose steeply from 53% in the 1981-1985 period to 72% in 2003-2007. Data on the CSIC show an increasing trend to publish in first quartile journals which has also been identified for the whole country. This practice is fostered by national and institutional policies on scientific evaluation (Jiménez-Contreras et al., 2003), which have also been implemented in other countries such as Australia (Butler, 2003), Belgium (Debackere and Glänzel, 2004) and Norway (Aksnes and Sivertsen, 2009).

Over the last decades, a growing internationalisation of science, partly due to cognitive and economic advantages derived from international collaboration, but also stimulated by various actions of scientific policy, has been described (Van Raan, 1997). Internationalisation is also a major target of CSIC's 'Strategic Plan' (CSIC, 2009) in order to enhance the international visibility of its research and the mainstreaming of its centres and institutes into the international community. Our study reveals a high internationalisation of the CSIC when compared against the national average, what can be explained by the more basic level of its research, its EU fundraising capacity (a major external financing source, second only to the «National Plan» —CSIC, 2009—), and its high level of activity in areas such as

Physics, where international collaboration is very large (see table I and figure 3). Furthermore, mention must be made that the CSIC owns a series of large infrastructures and shares the management of a few others (for example, the Spanish Antarctic Base, the Oceanographic Research Vessel 'Sarmiento de Gamboa' or the 'Calar Alto' Astronomic Centre), where scientists from several countries are involved and, therefore, enhance the development of research under international collaboration patterns

The comparison of CSIC with other similar European institutions is also relevant in order to position our institution in a broader context. In this regard, a previous study shows that CSIC's scientific production in 2003-2007 was slightly higher than that of the Italian CNR, but 1.3 times lower than the production of the German Max Planck Society, and 3.5 times lower than that of the French CNRS. The research impact of the CSIC, as occurs with the CNRS and the Max Planck Society, was above the average impact of their respective countries, and also above EU-27 and world averages. It is worth mention noting, in particular, the high impact values of the Max Planck Society, which were equal or higher than the world average in almost all disciplines (Bordons and González-Albo, 2008).

The CSIC: a perspective by area

First and foremost, it should be pointed out that research is a multidimensional activity. Since bibliometric studies, such as this one, only evaluate one dimension of the activity (the scientific dimension) and ignore others such as teaching, technological activity (inter alia, patents and technical assistance), consulting services and transfer to society (Laredo and Mustar, 2000), we only portray a partial view of the performance of institutions. Accordingly, we would like to emphasise here the importance of complementing bibliometric-based studies with other kind of indicators in research evaluation processes (Martin, 1996).

Once the above limitation has been mentioned, it is important to note that there are differences among subject areas in the sensitivity of the various indicators used to capture results. This study highlights the existing differences among CSIC's eight scientific-technical areas with respect to the type of research conducted, their habits of collaboration and their publication and citation practices; which, in the long term, induce differences in their productivity as measured through the WoS. These differences should be taken into account in the initial stage of a bibliometric study when the methodology is established (data sources, type of relevant data, indicators), and also in the final stage when the conclusions of the study are drawn.

Our study highlights the different coverage in WoS database by area, a fact that has been pointed out in the literature repeatedly, and which is largely determined by the national/international orientation of each area. Thus, Moed (2005) distinguishes among excellent coverage (Biological Sciences, Chemistry, Physics, etc.), good coverage (Geosciences, Engineering, Applied Chemistry, etc.) and moderate or poor coverage (Social Sciences and Humanities) (Moed, 2005).

Social Sciences, and especially Humanities, are found to be an extreme case of low coverage in the WoS. This is explained by several factors such as their more local scope —compared to natural or experimental sciences— which leads to a higher use of national journals, often written in local languages and given lesser coverage by international databases such as the WoS. Furthermore, the fragmented nature of Social Sciences and Humanities, in which various paradigms or schools of thought co-exist, is also a factor that makes finding a «basic core» of journals for each discipline a difficult task (Hicks, 1999; Archambault et al., 2006).

Our data about the level of coverage of the scientific production in each of CSIC's scientific-technical areas in WoS database are consistent with the above statement, and Hum. Soc. Sciences is the area which shows the poorest coverage. Although the performance of some Social Sciences disciplines, such as Psychology and Economics, is more similar to that of experimental sciences and said disciplines obtain a better coverage by the WoS (Hicks, 2004), the analysis of these differences is beyond the scope of this study.

In short, the poorest coverage in the WoS is found for those areas in which some document types not included in the database are important for the dissemination of research. Along this line, we can mention articles in national journals (not always well-covered by the WoS), books and monographs, which play a significant role in Social Sciences and Humanities (Hicks, 1999; Archambault et al., 2006); or reports, which are particularly important in technological areas.

To solve coverage-related problems mentioned above, WoS-based studies tend to use additional sources such as specialised international databases, national databases or internal sources (reports, institutional databases, etc.) for the analysis of areas poorly covered by the WoS (Archambault et al., 2009; De Filippo et al., 2011; Moed, 2005). In the case of studies on the CSIC carried out by the ACUTE group, ISOC and ICYT databases are used to analyse the Hum. Soc. Sciences and the Natur. Resources areas, respectively, with the aim of obtaining a more comprehensive overview of the production of CSIC scientists, covering both the national and the international dimensions. The use of the Scopus database, with a wider coverage of European journals, is an interesting option. However, very few differences in the main bibliometric indicators and rankings obtained in WoS and Scopus-based studies have been described in the literature, especially at the meso and macro levels (see, for example, Torres-Salinas et al., 2009, Archambault et al., 2009). Interestingly enough, in the context of the CSIC, the richness and variety of research results in the different areas is acknowledged by the institution to the extent that various types of results and publications are considered in the evaluation of centres and institutes conducted annually to assess the achievement of objectives, not only considering original articles, but also books and monographs[3] (with are especially relevant in Hum. Soc. Sciences) or patents (highly appraised in technological areas) (CSIC, 2009).

[3] Scientific production is weighted by the quality of publications (for example, maximum wight is assigned to those documents published in high impact factor journals —first quartile—).

Differences in group size and in the collaboration pattern adopted in each area can be explained by the type of research (theoretical or experimental), its complexity (mono or multidisciplinary) and the need to use expensive facilities. Research of the experimental type, which requires multidisciplinary approaches or large and costly equipments or facilities, takes particular advantage of collaboration. In some cases, research would not be possible without collaboration, since it facilitates the sharing of material, economic and intellectual resources (Katz and Martin, 1997). Prior studies have shown inter-area differences in collaboration, both in Spain (Gómez et al., 1995; Bordons and Gómez, 2000; Moya-Anegón et al., 2005; Bordons et al., 2010) and in other countries (Wuchty et al., 2007; Larivière et al., 2006; Glänzel, 2002). The high level of collaboration in Physics identified in our study can be related to *«big science»,* that is, research conducted in large facilities, such as the one developed for particle physics at the Swiss CERN.

The different impact of collaboration by area is a determinant factor of the differences observed between the total and the fractional count systems of scientific production; the latter resulting in a reduction of roughly 50% of CSIC's production. This reduction ranges from 20% in Hum. Soc. Sciences —where the lowest rate of collaboration is found—, to 59% in Physic. Sci. Tech., where there are many collaboration links between centres. With regards to the relative position of each area in decreasing order by production, the most important change is observed in Physics, which is ranked second by total count, behind Biol. Biomedicine, and drops to fifth position using the fractional count. In spite of the foregoing, our data show a good correlation between the total and fractional count of production by areas (Pearson's correlation coefficient = 0.970), which is found to be slightly lower if centres are considered (Pearson's correlation coefficient = 0.967). Although data about authors (micro level) are not available in this study, we consider that the counting system used may be especially influential at this level and cause substantial changes in the relative position of scientists. However, the good correlation observed for higher levels of aggregation supports our decision of using the total count system for the general analysis of the data involved.

In this study, we have identified differences among disciplines in the average number of citations per article as well as in the average impact factor of publications. A particular stress must be put on the fact that Biol. Biomedicine and Physic. Sci. Tech., the more basic areas, are the ones that obtain the highest values of citations per document. However, it is well-known that comparisons among disciplines are inappropriate due to differences in their citation habits. Differences in the citation density of disciplines (number of references per document) and in the ageing of the literature (half-life) are determinant factors that justify the need to standardise these indicators to make inter-area comparisons possible (Van Raan, 2004; Moed, 2005). The type of standardisation used in our study is the comparison of CSIC's citation-based indicators in each area or discipline with the corresponding values for the whole country. Other studies take the whole world as reference (see, for example, Van Leeuwen et al., 2003; Van Raan, 2004). The use of relative impact factor and relative citation rates enables us to observe that the CSIC tends to publish in better journals and to receive more citations than our country-average in various areas. This upholds the quality of the research carried out at the institution, although it may be influenced by some factors such as the predominance of basic research at the CSIC (which tends to receive more citations), and its high rate of international collaboration, for which a greater impact has been described in the literature (see for example Gazni and Didegah, 2011). Special mention should be made of the high impact of the CSIC in Multidisciplinary journals, Mathematics and Social Sciences, which is 40% higher than the national average. The publication of documents in prestigious journals such as *Science, Nature* or *PNAS* accounts for the high impact of the Multidisciplinary area, and it is primarily related to Biology and Biomedicine centres which are responsible for half of CSIC's publications in said area. Having papers accepted in these journals is a tough challenge, since they are very demanding (leading-edge subject, high level of originality, quality and relevance of the research) and have high rejection rates of originals, whilst the finally selected items attain high levels of visibility and recognition. As regards the fields of Mathematics and Social Sciences, although these two are small areas within the CSIC, there are some teams of scientists that conduct their activity on the basis of international criteria. Finally, the good correlation found between the impact factor and the number of citations per article in each of CSIC's eight areas is worth noting. Therefore, there is a manifest interest in getting papers published in high impact factor journals which are more visible and tend to exert a stronger influence on the scientific community.

Although the productivity by area is calculated in this article as the quotient between the number of documents and the number of researchers per area, this indicator should be analysed with caution because it is a very simple measure of productivity (Bonaccorsi and Daraio, 2003). The number of documents per researcher ratio only takes into account the production in the WoS, ignoring the influence of the structural and organisational features of each area. Not only there are differences in publication practices among disciplines the results of which are not equally covered in WoS database, but also there are other factors relevant to the productivity of researchers that are not taken into account, such as personal or demographic factors (age, professional category, gender), institutional factors (material and economic resources available) or organisational factors (see for example Dundar and Lewis, 1998). Furthermore, we have only considered civil servants, ignoring non-tenured staff or fellowship grantees who also contribute to the research, and technicians, whose participation is essential in certain experimental areas. The different impact of collaboration in each of the areas is also an influential factor as inter-area differences in productivity are reduced when the productivity is calculated on a fractional count basis. In short, we believe that observed inter-area differences in productivity can be more easily explained by the type of research and the publication practices of each area rather than by differences in the «efficiency» of scientists.

However, the calculation of productivity allows us to compare the present study with former ones on our institution or on analogous institutions. In as far as the international context is concerned, the study of Coccia (2005) points out that CSIC's WoS production in 2001 (1.93 documents/researcher) was higher than that of the Italian CNR (1.32) and the French CNRS (1.42), but lower than Max Planck's (2.05). However, once again it is necessary to approach these data with caution since, in addition to the limitations stated above, differences in the thematic profile of the institutions may influence the results. Therefore, an analysis by thematic area would be more precise and appropriate.

A number of studies in the literature offer data about productivity by subject areas, but the comparisons are difficult due to the differences in the kind of population under study (total number of researchers, only full-time researchers, or only researchers in specific rank levels), the definition of the relevant subject area, and the different institutional contexts. The average productivity of researchers in our work is higher than the one described in a study on Italian universities that considers nine areas within the «hard sciences» (Abramo et al., 2011) and its findings are also higher than the ones from a study dealing with several Norwegian universities in nine subfields of Natural Science and Medicine (Aksnes and Sivertsen, 2009). However, it is necessary to take into account that only civil servants are considered in our study ignoring non-tenured staff, whereas the above mentioned works deal with university staff who only devote a fraction of their time to make science (50% in the case of Norwegian universities). Moreover, it is worth mentioning that Chemistry shows the highest productivity in both studies, since also at the CSIC the Chem. Sci. Techn. area reaches a high productivity (1.83), very similar to that of Biol. Biomedicine (1.80), and only second to Material. Sci. Tech. (1.89), although the latter is not included as a subject area in the two studies mentioned above.

In the national context, an important increase of CSIC's productivity across all areas has taken place if the present results are compared with those of a prior study covering the 1984-1987 period (Méndez and Salvador, 1992). This finding does not come as a surprise since research has been getting ever more competitive in all areas over the years and having documents published in international journals is encouraged in Spain through the implementation of practices for the evaluation of research personnel, both at national level (Jiménez Contreras et al., 2003) and at institutional level (achievement of objectives and scientific promotion) (CSIC, 2009). In any event, the key point is not to publish a large number of documents (high productivity), but the quality of these papers and their contribution to the advance of science. Various authors point out that the policies aimed to promote a high number of publications run the risk of inducing high productivity but in lower-quality journals (see for example Butler, 2003). Fortunately, this behaviour has not been observed in Spain. Indeed, the case is quite the opposite. Our data show an increasing percentage of first quartile documents as well as a surge in the rate of citations per article (Bordons and González-Albo, 2008).

As regards the relation between funding and scientific production, we draw your attention to the fact that the data shown in this study give only an indicative and partial measurement of the cost of research, since only WoS-based publications and project-based funding are considered. Bearing in mind these limitations, our results show important differences by area that we would expect to be related with the experimental or theoretical nature of the area in question, the sophistication of equipment or the cost of the products used in the research. However, the outstanding high cost of publications in Biol. Biomedicine is striking, since it is higher than the one observed in Physic. Sci. Tech. despite the sophisticated facilities required in this area. This may be due to the fact that these infrastructures are shared by several countries through international agreements and alliances the cost of which is not reflected in the projects considered. Although the productivity (documents/researcher) of Physic. Sci. Tech. and Biol. Biomedicine is above CSIC's average, these areas also present the largest budget per project (CSIC, 2007), which ultimately results in a high cost per document. The high cost per document observed in Agricul. Sci. is more difficult to account for, but it may be influenced by the fact that this is the area (apart from Hum. Soc. Sciences) with the poorest coverage in the WoS (70%). In short, since only part of the information about input and output in research is available, it is necessary to be cautious when approaching these results. Given the interest and complexity of the subject, specific studies are needed to analyse research in its various facets.

In summary, this study gives evidence as to the important role of the CSIC in the framework of the Spanish research sector, analysed through its scientific publications with international scope, as well as its capacity to get documents published in the most prestigious journals and receive a higher number of citations than the national average. Moreover, the high internationalisation of the CSIC as measured by its links with co-authors from foreign countries is clearly shown. Finally, differences among CSIC's scientific-technical areas are described on the basis of different factors, such as the type of research (basic/applied nature, national/international scope, extent of scientific collaboration) and publication and citation practices. These inter-area differences, which undoubtedly exist at country level too, should be kept in mind when addressing planning issues and the interpretation of studies dealing with the evaluation of scientific activity within multidisciplinary institutions.

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