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A methodology for Institution-Field ranking based on a bidimensional analysis: the IFQ^2A index

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Abstract The problem of comparing academic institutions in terms of their research production is nowadays a priority issue. This paper proposes a relative bidimensional index that takes into account both the net production and the quality of it, as an attempt to provide a comprehensive and objective way to compare the research output of different institutions in a specific field, using journal contributions and citations. The proposed index is then applied, as a case study, to rank the top Spanish universities in the fields of Chemistry and Computer Science in the period ranging from 2000 until 2009. A comparison with the top 50 universities in the ARWU rankings is also made, showing the proposed ranking is better suited to distinguish among non-elite universities.

Keywords Rankings · Universities · Higher education · Bibliometrics · Shanghai ranking · Bidimensional analysis · Evaluation models · Research performance assessment · h-index

Introduction

There is an increasingly pressing demand for an objective way to measure the research output in terms of quantity and quality of different scientific agents (Buela-Casal et al. 2007; Dehon et al. 2010). The analysis and comparison of research output, whether it is among individuals or institutions, is a topic that has been raising an increasing amount of

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interest in the last few years. Most bibliometric studies focus on citations, tracking back to Price's original work in 1965 (Price 1965).

There are two main branches in academic ranking studies, the first of which tries to compare individual researchers productions and those that analyze institutions. In the first one, one of the most influential proposals is the h-index by Hirsch (Hirsch 2005), which has been subject of multiple extensions and corrections (Alonso et al. 2009). Other individual researcher indices have also been proposed extending the h-index, such as the g-index (Egghe 2006), q^2-index (Cabrerizo et al. 2010), and others (Bornmann et al. 2010; Kosmulski 2009).

The relevance of these rankings lays, for the most part, in the help it provides to allocate limited funds as fairly as possible. However, funding agencies often make their decisions based on partial or biased measures, resulting in unfair assessments of the production of some of the studied institutions. The research output of academic institutions is mostly meaningless in a vacuum, the interesting issue lays in the comparison between several institutions, often resulting in their ranking. There have been a number of proposals for this purpose (Dill and Soo 2005; Vieira and Gomes 2010), and according to Buela-Casal et al. (2007), 'there is a growing international convergence on the measurement of academic quality based primarily on research and production and on academic reputation'. Some of these rankings deal with worldwide universities, and they are mainly focused on the results and impact of research, which is why bibliometric indicators have a high importance in their composition. The most notable among them include:

– Academic Rankings of World Universities (ARWU) (Shanghai Jiao Tong University 2009). Provides a series of metrics and also an aggregation measure for them, resulting in a global ranking.
– Scimago Institutions Rankings (SIR) (SCImago Institutions 2007). Based upon the Scopus database (Elsevier B.V. Scopus 2010), it provides world and iberoamerican institutions rankings using differences indicators such as raw production, % of papers published in top quartile journals or normalized citation impact.
– Leiden rankings (Universiteit Leiden 2010). Ranks universities according to measures that are size-independent and normalized by the importance of each field (crown indicators). It has also been used to compare research group productions' (Moed 2010).
– QS World University Rankings (QS World University 2010). Provides both a general rank and also a field-by-field analysis. Quite different from the others due to its employment of a number of non-bibliometric measures.

The previously mentioned rankings all provide a global analysis of universities; but some of them also study each subject field independently. The ARWU field rankings are probably the better known studies in this line.

These types of issues and the different rankings derived (Aguillo et al. 2010) have provoked some controversy around university rankings. Adler and Harzing claim that it is necessary to have 'an immediate examination of existing ratings systems, not only as a legitimate scholarly question vis a vis performance—a conceptual lens with deep roots in management research—but also because the very health and vibrancy of the field are at stake' (Adler and Harding 2009). They are worried about how the current system rewards raw production rather than 'scholarship that addresses the questions that matter most to society'.

Due to the importance of studying each subject field separately; as most rankings focus on top universities using elitist indicators, and because of the concerns expressed by some authors in regard with the inadequacy of most bibliometric indicators when applied to smaller size institutions (Sypsa and Hatzakis 2009); a new methodology is needed. Said methodology should take into account these factors in order to create rankings that allow the comparison between universities that cannot reach tops 100, 250 or 500 worldwide, and do so in a given subject field.

This contribution presents a bidimensional quantitative-qualitative index to compare the research output of a group of institutions in a given field (what we call Institution-Field).

- The quantitative dimension shows the net production of an Institution-Field during a period of time by using raw indicators that may be correlated with staff of the institution.
- The qualitative dimension (which can be seen as a measurement for academic excellence) focuses on the ratio of high-quality production on each Institution-Field during the same period of time, and is mostly independent of the size of the institution.

A combination of both dimensions provides a robust and objective way to compare research outputs. We have named this measure the Institution-Field Quantitative and Qualitative Analysis index (IFQ^2A index).

This paper is organized as follows: in "Methodology: The IFQ2A index" section the proposed indicator is described. "Case study" section includes a case study with data from Spanish universities in the fields of Chemistry and Computer Science, along with Principal Component and correlation analysis among the indicators that compose the IFQ^2A index, and a comparison with the ARWU ranking. Lastly, some concluding remarks are made in "Concluding remarks" section.

Methodology: The IFQ^2A index

This section is divided as follows: in "Definition and mathematical conceptualization of the IFQ2A index" subsection, the proposed index is explained and justified, while the procedure to obtain the data is presented in "Information processing" subsection.

Definition and mathematical conceptualization of the IFQ^2A index

Focusing on the idea of ranking a set of universities by their research output in a given field, we propose a new ranking that:

- Does not take into account elitist measures such as Nobel, Turing or Fields medals awards obtained by alumni, since these type of indicators only favor elite universities and make it harder to differentiate between the rest.
- Provides an aggregated ranking that makes it easier for decision makers to analyze where each university is ranked within its context.
- Takes into account the relative size of the university by providing a bidimensional quantitative-qualitative index, to avoid giving an unfair advantage to bigger institutions.

The IFQ^2A index can be formally defined as a bidimensional bibliometric measure to compare and rank different institutions according to their research output and impact in a given field. The indicators considered in both dimensions correspond to:

- QuaNtitative Institution-Field index (*QNIF*), based on raw number of publications, citations and h-index (Hirsch 2005).

– QuaLitative Institution-Field index (*QLIF*), based on relative measures of impact and visibility, i.e. JCR journal first quartile, average citations and ratio of highly cited papers. The "qualitative" denomination is linked to academic excellence in this work.

We have used six bibliometric indicators to compute the two partial indices *QNIF* and *QLIF*, detailed in Table 1.

A brief justification for the chosen measures follows:

– *NDOC*: Basic indicator for total amount of raw production, it may depend on the number of researchers in the institution focused on the field of study, and how active they are.
– *NCIT, ACIT, TOPCIT*: According to Bornmann and Daniel (Bornmann and Daniel 2008), 'In bibliometrics the resonance, or impact, of a scientific work is measured via the number of citations. It can be assumed that the more important a work is for the further development of a field, the more frequently it is cited.' That is, NCIT is a raw indicator of scientific relevance, and ACIT and TOPCIT indicate quality of the research output and ratio of very high-quality papers (Aksnes 2003, Aksnes and Sivertsen 2004), respectively.
– *H-index*: Probably the better known index in current bibliometrics, it has proven to be a robust measure of impact. By limiting its scope to the period of study, we avoid the seniority dependence the basic h-index usually presents.
– *%1Q*: The impact factor is widely considered a reliable measure of journal quality (Bornmann and Daniel 2008), so centering the analysis in the top quartile provides an indicator of top-quality papers. The ratio of citable papers that are top-quality serves as a relative size-independent indicator, %1Q.

These measures are normalized in [0, 1], setting the highest value to 1, and the rest proportionally.

QNIF and *QLIF* are respectively calculated as

$$QNIF = \sqrt[3]{I1 \times I2 \times I3} \quad (1)$$

Table 1 Bibliometric measures used to calculate *QNIF* and *QLIF*

Code	Measure	Character	Dimension	Description
I1	NDOC	Quantitative	Output	Raw number of citable papers published in scientific journals: articles, reviews letters, notes or proceeding papers
I2	NCIT	Quantitative	Observed	Number of citations received by all impact citable papers
I3	H-index	Quantitative	Observed impact	h-index, as proposed by Hirsch, over all the publications of the institution.
I4	%1Q	Qualitative	Journal quality	Ratio of papers published in journals in the top JCR quartile ($\frac{100 * N1Q}{NDOC}$)
I5	ACIT	Qualitative	Observed impact	Average number of citations received by all citable papers
I6	TOPCIT	Qualitative	Observed impact	Ratio of papers that belong to the top 10% most cited (highly cited)[a]

[a] The top 10% most cited papers are calculated within the group of interest. For example, if the institutions in the study have published 194821 papers, a paper is considered highly cited if it is among the 19482 most cited.

$$QLIF = \sqrt[3]{I4 \times I5 \times I6} \quad (2)$$

We can define an index that aggregates the two previous ones as a hypervolume measure (the surface area associated to both indices, the area under the position in the map):

$$IFQ^2A = QNIF \times QLIF \quad (3)$$

This approach provides a high interpretability, since the index can be shown in a 2-dimensional graph where the end user can easily identify the relative ranking of the institutions both in terms of raw production and quality of production.

A summary of the procedure to calculate the IFQ^2A index over a set of Institution-Fields can be found in Algorithm 1.

Algorithm 1 IFQ^2A index calculation procedure

1. Obtain measures I1,…,I6 for the period of interest from the ISI Web of Science.
2. Normalize measures I1,…,I6 in [0, 1], setting the maximum to 1 and the rest proportionally.
3. Calculate *QNIF* and *QLIF* from the normalized values applying Eqs. 1 and 2.
4. Calculate IFQ^2A from *QNIF* and *QLIF* applying Eq. 3.

Information processing

First, the set of universities and knowledge field of interest need to be chosen, along with a period of time. Once they are decided, the data is downloaded. The research output of each university indexed in the Science Citation Index of the ISI-Web of Knowledge (http://isiknowledge.co), using the field "Address" as a filter and taking into account all the different names each university receives. Next, the production of each of the universities within the field of interest is extracted. A scientific work is considered to be part of the field if it was published in a journal indexed in one of the eight JCR journal categories in Table 2. In order to calculate the indicators related to journal Impact Factor, the editions of the JCRs for the period of time of interest should be used.

Once the data is compiled into a relational database, the indicators defined in Table 1 are computed, and the IFQ^2A index for each university is calculated according to Algorithm 1.

With the goal of comparing the results obtained by the proposed indicator against those in existing rankings, the IFQ^2A index was also calculated for the universities included in the top 50 of the ARWU-subject ranking 2010 in the fields of Chemistry and Computer Science (Shanghai Jiao Tong University 2009). The ARWU ranking was chosen since it is the only one among the research-oriented rankings that provides per-field classifications. The indicators were calculated as described above, with the only difference being the period of study, 2005–2009 in this case. Finally, the correlation between the IFQ^2A index and the ARWU-subject ranking was studied and the difference in university positioning analyzed.

Case study

This section is divided as follows: "Spanish universities in the fields of Chemistry and Computer Science" subsection defines the specific domain for an example study to showcase the application of the IFQ^2A index: the set of all Spanish universities in the fields of Chemistry and Computer Science. In "Principal Component and Correlation analysis for

Table 2 Thomson Reuters—JCR Chemistry and Computer Science categories

Field: Chemistry	Field: Computer science
Chemistry, Analytical	Computer Science, Artificial Intelligence
Chemistry, Applied	Computer Science, Cybernetics
Chemistry, Inorganic and Nuclear	Computer Science, Information Systems
Chemistry, Medicinal	Computer Science, Interdisciplinary Applications
Chemistry, Multidisciplinary	Computer Science, Hardware and Architecture
Chemistry, Organic	Computer Science, Software Engineering
Chemistry, Physical	Computer Science, Theory and Methods
Electrochemistry	Imaging Science and Photographic Technology
Polymer Science	

the validation of the IFQ2A index" subsection, an analysis of the aggregations among indicators and partial indices is presented, based on principal component analysis and Pearson correlations. "Ranking of the Spanish universities in Chemistry according to the IFQ2A index" subsection presents the results of the application of the IFQ^2A index to the case study. Lastly, an analysis of the similarities and differences between the IFQ^2A index and the ARWU-subject rankings is shown in "Comparing with the ARWU-subject ranking for Chemistry and Computer Science" subsection.

Spanish universities in the fields of Chemistry and Computer Science

For the validation and practical application example of the IFQ^2A index, the fields of Chemistry and Computer Science, and the set including all Spanish universities were chosen. The field of Chemistry was chosen due to being one of the best represented within Thomson Reuters' databases (Moed 2005), with 640 JCR journals. Computer Science was selected because it is a well-defined one with 535 Journal Citation Reports (JCR) journals; but also one where a relevant part of the production is not represented within said databases; thus providing a measure of the stability of the index. Two different fields were selected to obtain a broader picture of the usefulness of the proposed index, along with its stability. The choice of Spanish universities was due to them being underrepresented in the main worldwide rankings. Once the framework of study was fixed, the period ranging from 2000 until 2009 was chosen as the period of study.

Principal component and correlation analysis for the validation of the IFQ^2A index

To validate the grouping of indicators that make up the *QNIF* and *QLIF* indices, we first performed a Principal Component Analysis (PCA) over the data obtained for the set of Spanish universities in the fields of Chemistry and Computer Science. The results of this analysis are shown in Table 3; and suggest that data can be reduced to a bidimensional representation where the first dimension is composed of NDOC, NCIT and H (which corresponds to *QNIF*); and the second one is composed of %1Q, ACIT and TOPCIT (*QLIF*).

Table 3 PCA of the six bibliometric indicators used to compute the IFQ^2A index

Chemistry	*QNIF*	*QLIF*
NDOC	1.042	
NCIT	0.990	
H	0.870	
%1Q		0.789
ACIT		0.877
TOPCIT		0.897
Computer Science	***QNIF***	***QLIF***
NDOC	1.035	
NCIT	0.944	
H	0.843	
%1Q		0.941
ACIT		0.784
TOPCIT		0.859

Values lower than absolute 0.300 omitted

The correlations between each single bibliometric indicator are shown in Table 4, obtained from the universities analyzed. There are correlations within the quantitative indicators (NDOC, NCIT, and H), and also, but to a lesser degree, within the qualitative ones (%1Q, ACIT and TOPCIT). What is more interesting is that the correlations among crossed indicators (a quantitative indicator with a qualitative one) are in general very low, with ACIT and H being the highest one at 0.6810 in Chemistry. We consider this correlation low enough to conclude that the *QNIF* and *QLIF* indices are composed of indicators that describe different information.

Regarding the correlation between the *QNIF* and *QLIF* index, Table 5 shows how they correlate against each other, and also against each of the individual bibliometric indicators in Table 1. Both *QNIF* and *QLIF* correlate strongly with the indicators that compose them (which shows they manage to synthetize the information of three indicators each); but the correlation between them (*QNIF* against *QLIF*) is extremely low, indicating they are independent and thus the IFQ^2A index is a truly bidimensional measure.

Judging by these results, it would seem justifiable to substitute the six original indicators for the two constructed variables obtained from PCA. The main limitation of this approach would be the loss of interpretability of the rankings for decision makers, since measures $I1,...,I6$ are easily understandable while artificially constructed variables would be much harder to understand. For this reason, we believe keeping all 6 indicators and obtaining the bidimensional ranking by aggregating them is a better solution.

Ranking of the Spanish universities in Chemistry according to the IFQ^2A index

This subsection shows the IFQ^2A index rankings for the top Spanish universities in Chemistry. As an example, Table 6 shows the raw values of the six bibliometric indicators along with the normalized ones for each university. Only the top 20 universities are shown due to space concerns.

Table 7 and Fig. 1 show the results for the partial quantitative index *QNIF*, the qualitative one *QLIF* and also for the IFQ^2A index which determines the rankings, for all the universities studied. It is remarkable how the IFQ^2A index achieves a balance between

Table 4 Correlation analysis among basic indicators. Data from the top 75% Spanish universities in 2000-2009

Chemistry	NDOC	NCIT	H	%1Q	ACIT	TOPCIT
NDOC	1	0.9840	0.8950	0.1670	0.3800	0.3430
NCIT		1	0.9390	0.2200	0.5090	0.4750
H			1	0.2340	0.6810	0.6290
%1Q				1	0.4260	0.4230
ACIT					1	0.9440
TOPCIT						1
Computer Science	NDOC	NCIT	H	%1Q	ACIT	TOPCIT
NDOC	1	0.8986	0.8122	-0.0669	0.1845	0.1750
NCIT		1	0.8721	0.1637	0.5394	0.4097
H			1	0.2901	0.5089	0.6608
%1Q				1	0.5724	0.6722
ACIT					1	0.6819
TOPCIT						1

Table 5 Correlation analysis of *QNIF* and *QLIF* against the basic indicators. Data from the top 75% Spanish universities in 2000-2009

Chemistry	NDOC	NCIT	H	%1Q	ACIT	TOPCIT	*QNIF*	*QLIF*
QNIF	**0.988**	**0.994**	**0.952**	0.205	0.498	0.453	1.000	0.470
QLIF	0.362	0.489	0.635	**0.604**	**0.954**	**0.971**	0.470	1.000
Computer Science	NDOC	NCIT	H	%1Q	ACIT	TOPCIT	*QNIF*	*QLIF*
QNIF	**0.959**	**0.972**	**0.923**	0.099	0.414	0.394	1.000	0.368
QLIF	0.133	0.440	0.582	**0.836**	**0.863**	**0.914**	0.368	1.000

quantity and quality of production, shown as an example in a university that can achieve a high ranking with a small research output if said output is high-quality; the *Universitat Politècnica de València*.

The situation described above is well represented in Fig. 1, where we can place each university in a quadrant. That way, the top right area includes the high-production universities with high-quality research, the bottom right shows the high-production ones with a lower impact, top left includes small but high-impact universities and finally bottom left those that do not stand out in any of the dimensions.

Comparing with the ARWU-subject ranking for Chemistry and Computer Science

This subsection includes a comparison between the IFQ^2A index and the ARWU-subject rankings for the fields of Chemistry and Computer Science. To do so, the IFQ^2A index was calculated for the universities in the top 50 of the ARWU-subject ranking of Computer Science in 2010. A summary of the results is presented in Tables 8 and 9 for Chemistry and CS respectively (see http://www.rankinguniversidades.es/ARWU_Comparison.xls for the

Table 6 Raw and normalized bibliometric measures for the top 20 Spanish universities in Chemistry (2000–2009)

	Raw bibliometric measures						Normalized bibliometric measures					
	Quantitative			Qualitative			Quantitative			Qualitative		
Institution	I1	I2	I3	I4	I5	I6	I1	I2	I3	I4	I5	I6
Barcelona	4210	57742	77	0.594	13.715	0.127	1.000	1.000	1.000	0.856	0.822	0.802
Valencia	3334	44194	67	0.573	13.256	0.118	0.792	0.765	0.87	0.825	0.794	0.745
Polit. Valencia	1665	27116	64	0.651	16.286	0.148	0.395	0.47	0.831	0.938	0.976	0.931
Complutense	2679	32941	62	0.528	12.296	0.111	0.636	0.57	0.805	0.76	0.737	0.699
Aut. Madrid	1943	28476	64	0.562	14.656	0.132	0.462	0.493	0.831	0.809	0.878	0.833
Zaragoza	1942	24606	52	0.607	12.67	0.119	0.461	0.426	0.675	0.874	0.759	0.749
País Vasco	2302	26793	59	0.527	11.639	0.095	0.547	0.464	0.766	0.759	0.697	0.597
Santiago Compostela	2651	30541	55	0.476	11.521	0.085	0.63	0.529	0.714	0.685	0.69	0.537
Alicante	1263	20654	62	0.511	16.353	0.143	0.3	0.358	0.805	0.737	0.98	0.903
Aut. Barcelona	2001	23449	51	0.6	11.719	0.095	0.475	0.406	0.662	0.864	0.702	0.598
Oviedo	1717	20704	47	0.683	12.058	0.097	0.408	0.359	0.61	0.984	0.722	0.613
Rovira i Virgili	1242	16933	53	0.647	13.634	0.134	0.295	0.293	0.688	0.931	0.817	0.842
Jaume I Cast.	838	13989	48	0.617	16.693	0.159	0.199	0.242	0.623	0.888	1.000	1.000
Sevilla	1506	15747	44	0.533	10.456	0.082	0.358	0.273	0.571	0.767	0.626	0.515
Vigo	1441	17153	51	0.38	11.904	0.083	0.342	0.297	0.662	0.548	0.713	0.52
Granada	1470	15604	45	0.49	10.615	0.076	0.349	0.27	0.584	0.705	0.636	0.476
Murcia	906	10180	39	0.613	11.236	0.086	0.215	0.176	0.506	0.882	0.673	0.542
Córdoba	1099	10641	35	0.67	9.682	0.058	0.261	0.184	0.455	0.964	0.58	0.367
La Laguna	869	9571	39	0.501	11.014	0.085	0.206	0.166	0.506	0.721	0.66	0.537
Girona	699	8674	38	0.522	12.409	0.1	0.166	0.15	0.494	0.752	0.743	0.631

Table 7 Ranking of the top Spanish Universities in the field of Chemistry during the period 2000–2009 according to the IFQ^2A index

Institution	*QNIF*	*QLIF*	IFQ^2A	Rank
Barcelona	1	0.826	0.826	1
Valencia	0.808	0.787	0.636	2
Polit. Valencia	0.536	0.948	0.508	3
Complutense	0.664	0.731	0.485	4
Aut. Madrid	0.574	0.839	0.482	5
Zaragoza	0.51	0.792	0.404	6
País Vasco	0.579	0.681	0.394	7
Santiago Compostela	0.62	0.633	0.392	8
Alicante	0.442	0.867	0.383	9
Aut. Barcelona	0.504	0.713	0.359	10
Oviedo	0.447	0.758	0.339	11
Rovira i Virgili	0.391	0.862	0.337	12
Jaume I Cast.	0.311	0.961	0.299	13
Sevilla	0.382	0.628	0.24	14
Vigo	0.407	0.588	0.239	15
Granada	0.381	0.598	0.227	16
Murcia	0.268	0.685	0.184	17
Córdoba	0.28	0.59	0.165	18
La Laguna	0.259	0.634	0.164	19
Girona	0.231	0.707	0.163	20
Castilla la Mancha	0.261	0.62	0.162	21
Valladolid	0.273	0.546	0.149	22
Almería	0.191	0.722	0.137	23
Salamanca	0.227	0.6	0.136	24
Málaga	0.216	0.629	0.136	25
Islas Baleares	0.165	0.791	0.13	26
A Coruña	0.211	0.582	0.123	27
Cádiz	0.17	0.596	0.101	28
Polit. Catalunya	0.23	0.44	0.101	29
Alcalá Henares	0.184	0.505	0.093	30
UNED	0.152	0.608	0.092	31
Extremadura	0.185	0.489	0.09	32
La Rioja	0.121	0.715	0.086	33
Burgos	0.146	0.553	0.081	34
Pública Navarra	0.094	0.852	0.08	35
Huelva	0.102	0.769	0.079	36
Navarra	0.111	0.575	0.064	37
Lleida	0.089	0.677	0.06	38
Jaén	0.13	0.412	0.054	39
Polit. Madrid	0.107	0.477	0.051	40
Miguel Hernández	0.069	0.472	0.032	41

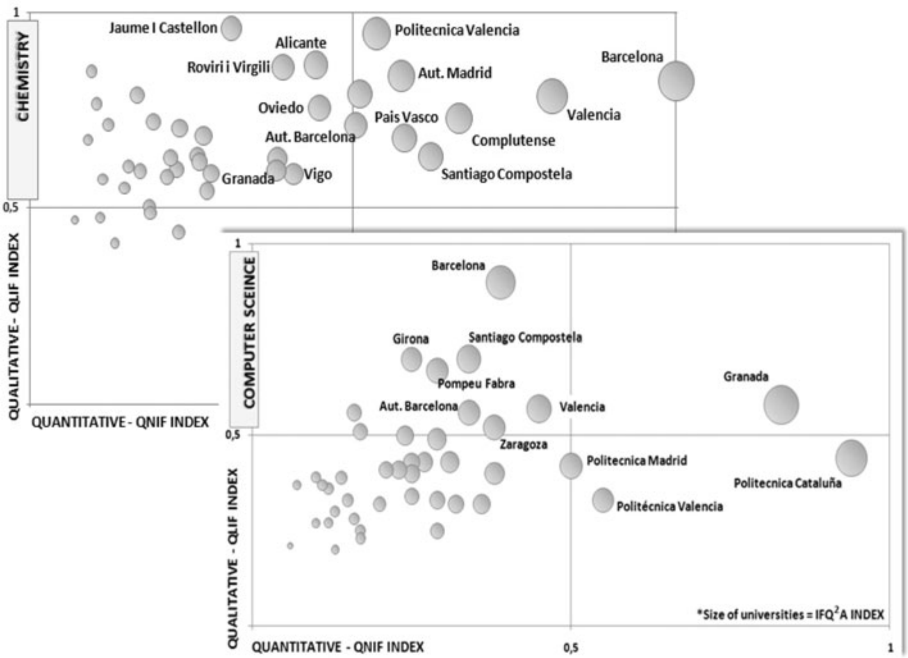

Fig. 1 Bidimensional mappings for Chemistry and Computer Science, top Spanish universities during 2000–2009 ranked by the IFQ^2A index

values of the bibliometric indicators). Both rankings are fairly different, with the average correlation between total scores being 0.648 and 0.628 in ranks in the field of Chemistry, and 0.757 for scores, 0.630 between ranks in Computer Science.

The main difference in the rankings appears in universities with low or no score in the Alumni, Award or HiCi indicators, since they include a different information from the one used to compose the IFQ^2A index. For example, the rank given in the field of Computer Science to institutions like Harvard University, California Institute of Technology (Caltech) o Swiss Federal Institute of Technology is significantly better in IFQ^2A index than in ARWU. On the other hand, institutions with a mid-level production but high scores in Alumni, Award or HiCi are ranked higher in ARWU than in IFQ^2A index rankings, such as the Weizmann Institute of Science. A similar phenomenon can be observed in the Chemistry study, with institutions like California Davis and Illinois Urbana-Champaign having a much better rank according to the IFQ^2A index; and Columbia having a much lower rank.

Concluding remarks

The IFQ^2A index is a bidimensional bibliometric measure that summarizes six bibliometric indicators to compare the research output of academic institutions in a given field, both in terms of raw output and relative quality of their research output, providing an easily interpretable bidimensional graphical ranking of the institutions of interest.

The proposed ranking has as its primary goal to capture the international research of highest impact and visibility; for this reason the calculation of the IFQ^2A index has to be made from international citation tools that also include journals impact assessment; so a

Table 8 Ranking of the top 50 institutions in the ARWU-subject ranking for the field of Chemistry during the period 2005–2009 according to the IFQ^2A index

Institution	ARWU		IFQ^2A	
	Total	Rank	Total	Rank
California Berkeley	100	1	0.744	1
MIT	80.5	8	0.609	2
Northwestern	76.1	10	0.558	3
Harvard	98.7	2	0.481	4
Georgia Inst. Tech.	58.5	38	0.465	5
California Davis	58.5	39	0.465	6
Illinois Urbana-Champaign	61.3	32	0.459	7
Tokyo	74.6	11	0.438	8
Michigan Ann Arbor	60.4	35	0.436	9
California Los Angeles	70.2	15	0.435	10
Stanford	94	4	0.426	11
Cambridge	97.8	3	0.396	12
Kyoto	82.5	7	0.392	13
California Santa Barbara	68.2	18	0.386	14
Swiss Fed. Inst. Tech. Zurich	87	5	0.364	15
California Inst. Tech.	85.2	6	0.358	16
Texas Austin	67.6	19	0.340	17
Minnesota Twin Cities	63.5	28	0.319	18
Imperial College	62.3	30	0.315	19
Oxford	76.4	9	0.295	20
Rice	66.2	20	0.292	21
Cornell	64.7	23	0.290	22
Purdue W Lafayette	64.1	27	0.270	23
Pennsylvania	68.4	17	0.270	24
Toronto	64.6	24	0.258	25
Wisconsin Madison	56.9	44	0.253	26
Tohoku	62.6	29	0.249	27
Texas A&M	64.6	25	0.242	28
California San Diego	69.8	16	0.230	29
Yale	65.5	21	0.224	30
N Carolina Chapel Hill	60.8	33	0.223	31
Florida	60.6	34	0.215	32
Tokyo Inst. Tech.	60.1	36	0.215	33
Columbia	74.2	12	0.214	34
Utrecht	57	43	0.206	35
Strasbourg	71	14	0.205	36
Stockholm	55.1	47	0.202	37
Swiss Fed. Inst. Tech. Lausanne	58.3	41	0.191	38
University of Chicago	65.4	22	0.186	39
Tech. Uni. Munich	73.1	13	0.185	40
Nagoya	62.1	31	0.181	41

Table 8 continued

Institution	ARWU		IFQ^2A	
	Total	Rank	Total	Rank
California Irvine	64.6	26	0.179	42
Iowa St.	54.7	50	0.173	43
Washington St. Louis	54.9	48	0.152	44
Southern California	57.3	42	0.147	45
Wuerzburg	59.1	37	0.140	46
Colorado Boulder	58.4	40	0.140	47
Goettingen	55.2	46	0.136	48
Ohio St. Columbus	54.9	49	0.134	49
Heidelberg	55.5	45	0.131	50

Table 9 Ranking of the top 50 institutions in the ARWU-subject ranking for the field of Computer Science during the period 2005–2009 according to the IFQ^2A index

Institution	ARWU		IFQ^2A	
	Total	Rank	Total	Rank
MIT	94.8	2	0.706	1
Stanford	100	1	0.676	2
Harvard	65.6	9	0.620	3
California Berkeley	82.7	3	0.595	4
California Inst. Tech.	63	11	0.497	5
Swiss Fed. Inst. Tech. Zurich	54.4	24	0.470	6
Illinois Urbana-Champaign	62.5	13	0.441	7
Maryland College Park	61.9	14	0.407	8
California Los Angeles	54.1	25	0.383	9
California San Diego	58.5	16	0.347	10
Minnesota Twin Cities	46.3	42	0.337	11
Princeton	78.7	4	0.335	12
Carnegie Mellon	76.4	5	0.328	13
Columbia	56.2	20	0.306	14
Georgia Inst. Tech.	54.6	23	0.303	15
Washington	55	22	0.297	16
Toronto	65.5	10	0.296	17
City Univ. Hong Kong	45.1	45	0.294	18
Southern California	66.6	7	0.293	19
National Univ. Singapore	45	46	0.289	20
Cornell	67.9	6	0.286	21
Tel Aviv	49.2	31	0.275	22
Cambridge	50.2	30	0.268	23
Texas Austin	66.3	8	0.266	24
Michigan Ann Arbor	57.4	18	0.262	25
British Columbia	50.9	29	0.257	26

Table 9 continued

Institution	ARWU		IFQ^2A	
	Total	Rank	Total	Rank
Technion Israel Inst. Tech.	61.1	15	0.248	27
Pennsylvania	46.6	41	0.234	28
Manchester	46.3	42	0.228	29
Oxford	57.5	17	0.228	30
California Davis	44.1	50	0.227	31
Purdue W Lafayette	56.6	19	0.217	32
Ohio St. Columbus	47.9	38	0.216	33
Chinese Univ. Hong Kong	48.3	35	0.208	34
N Carolina Chapel Hill	48.3	35	0.208	35
Hong Kong Univ. Sci.&Tech.	52.2	26	0.202	36
California Irvine	48.1	37	0.197	37
Yale	49.2	31	0.195	38
Rutgers	47.4	39	0.192	39
Brown	44.2	49	0.176	40
California Santa Barbara	45.3	44	0.176	41
Duke	48.9	34	0.169	42
Weizmann Inst. Science	62.8	12	0.139	43
National Chiao Tung Univ.	48.2	36	0.137	44
Colorado Boulder	49	33	0.135	45
Hebrew Univ. Jerusalem	55.4	21	0.134	46
Northwestern	44.1	50	0.132	47
National Taiwan Univ.	51	28	0.131	48
Ghent	44.8	47	0.107	49
Massachusetts Amherst	46.7	40	0.077	50
Oslo	44.6	48	0.068	51

similar ranking could also be extracted from the Scopus database instead of the ISI-Web of Knowledge. Also, given its exclusively bibliometric nature, there are two points to clarify:

1 The IFQ^2A index is applicable only to fields that can be configured from the categories present in the JCR or similar.
2 The period of study should encompass at least five years so that the citation indicators are consistent and significative.

The IFQ^2A index follows the line of other bibliometric rankings such as the CWTS-Leiden (Universiteit Leiden 2010) or more recently the SCImago Institutions Rankings (SIR) (SCImago Institutions 2007). Regarding the Leiden ranking, and considering the criticism received recently by its "Crown Indicator" (Leydesdorff and Opthof 2010; van Raan et al. 2010), the IFQ^2A index provides more transparent and easy to replicate rankings. Its advantage over the SIR rankings is that it provides a global measure that aggregates the indicators used. Lastly, in its comparison with the ARWU-subject rankings (Shanghai Jiao Tong University 2000), the main advantage the IFQ^2A index provides is the avoidance of the elitist indicators (Alumni, Award and HiCi) which might be more indicative of quality past than present (Billaut et al. 2010), a problem that is aggravated by the high weight (over 50% combined) these indicators have in the ARWU ranking (Liu and Cheng 2005).

Lastly, a comprehensive study of the state of research in Spanish universities by field (considering twelve different knowledge areas) has been carried out using the IFQ^2A index, and can be found in http://www.rankinguniversidades.es. In that same website, under the url http://www.rankinguniversidades.es/ARWU_Comparison.xls; a document with all the indicators for the top 50 ARWU universities in Chemistry and Computer Science is included.

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