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Advantages and limitations in the use of impact factor measures for the assessment of research performance in a peripheral country

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Impact factor is a quasi-qualitative indicator, which provides a measurement of the prestige and international visibility of journals. Although the use of impact factor-based indicators for science policy purposes has increased over the last two decades, several limitations have been pointed out and should be borne in mind. The use of impact factor should be treated carefully when applied to the analysis of peripheral countries, whose national journals are hardly covered by ISI databases. Our experience in the use of impact factor based indicators for the analysis of the Spanish scientific production is shown. The usefulness of the impact factor measures in macro, meso and micro analyses is displayed. In addition, the main advantages, such as the great accessibility of impact factor and its ready-to-use nature are pointed out. Several limitations such as the need to avoid inter-field comparisons or the convenience of using a fixed journal set for international comparisons are also stressed. It is worth noting that the use of impact factor in the research evaluation process has influenced strongly the publication strategy of scientists.

Introduction

The use of the journal impact factor (IF) produced regularly by the Institute for Scientific Information (ISI) and published in the *Journal Citation Reports* (JCR) is increasing, not only amongst the bibliometric community, but also amongst researchers and science policy makers. Some of the reasons that explain its success are the quasi-qualitative nature of IF and its great accessibility, since it is directly provided by ISI for the most international and visible journals. The IF of a certain journal is used as a proxy of the quality and expected impact of each of the papers published in it.

In spite of these advantages, the use of IF measures as visibility indicators shows some caveats, which have been pointed out in different studies (*Gómez* and *Bordons*, 1996; *Amin* and *Mabe*, 2000), and even by the ISI professionals (*Garfield*, 1998).

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These shortcomings are particularly important for non-central countries, whose national journals are scarcely covered by ISI databases (*Arunachalam* and *Manorama*, 1988; *Osareh* and *Wilson*, 1995). Thus, only the most international part of the scientific production of these countries is registered, and their national journals, if covered, often show very low IF.

This paper focuses on the main advantages and limitations detected in the use of IF as a quasi-qualitative indicator for the assessment of the Spanish scientific activity. Most of the data here presented are based on our experience at the bibliometric department of CINDOC-CSIC, where we have worked in quantitative studies of science and technology since the eighties. The international databases SCI, SSCI and A&HCI are the ones we most frequently use in our studies (when international visibility is required), together with the Spanish database ICYT (for national data) or specialised databases in the analysis of specific areas. In our studies based on the ISI databases, the IF and other related indicators – such as relative impact factor or normalised position – are frequently used. The advantages and shortcomings of the different indicators vary according to the units of analysis of the studies, therefore our experience in the different aggregation levels is shown separately below.

Basic assumptions in the use of the impact factor measures

The IF of a journal is used in the literature as a measure of expected citations for each of the papers published in it, that is as an indirect measure or proxy of their quality and impact. It can be obtained easily and immediately, with no time-lag after the publications are produced.

However, the value of the impact factor is affected by different factors such as subject area, type of documents or length of the citation measurement window. A higher impact factor has been described for reviews than for other document types, and basic research also shows higher impact factors than applied science. Moreover, the two-year citation window of the JCR IF is considered too short to detect the real impact of publications in "slow" evolving disciplines. In consequence, impact factors should be used with caution and comparisons should be limited to comparable units.

Another critical comment about impact factor measures is that the distribution of citations within a journal is very skewed, and a large percentage of papers in a journal receive no citations at all. However, impact factor validity is supported by the strong negative correlation described between the value of the IF and the degree of uncitedness (*van*

Leeuwen et al., 1999). Finally, a lack of correlation between observed and expected citations has been reported by different authors (*Seglen*, 1992), this is especially true for peripheral countries' papers, which are less cited than those of central countries.

In any case, we can assume that the highest IF journals within each discipline are the most prestigious ones and show the highest diffusion. The quality of documents published in these journals is almost guaranteed by the strict process of peer review that precedes the acceptance of documents for publication. Although it does not show the real or observed impact of each of the papers analysed, it is quite useful when applied to statistically significant sets of documents.

Once we assume the validity of impact factor measures in bibliometric studies, it is essential to face some methodological issues, such as the following: Is it necessary to use annual impact factors when we analyse the production of several years? Or, could we use the value of a central year in the analysed series? Are impact factor measures equally valid for all types of documents? Or, should they be limited to certain document types?

In our studies, which are focused on the analysis of the Spanish scientific production, the impact factor of an intermediate year is used for the study of three or four-year periods. In fact, slight variations have been described for the impact factor of established journals from year to year (*Amin* and *Mabe*, 2000). However, impact factors of different years are used in our studies if the length of the analysed period exceeds the four years.

In our analyses dealing with IF measures we consider only "citable items", that is, those document types used by ISI to calculate IF. We are aware that for a detailed study each document type should be analysed separately, since reviews have, in general, a higher impact than most other document types (articles, letters, notes) (*Van Leeuwen* et al., 1999).

Thematic differences

Average IF of the whole Spanish production is avoided in our studies because of the observed differences in the publication habits of scientists from diverse disciplines. Differences in the activity profile of countries over disciplines may influence the resulting IF, thus favouring the "life sciences-oriented" countries (such as the UK) vs. the more "technologically-oriented" ones (Germany or Japan), since a higher impact factor is usually observed for basic science than for the more applied science. Impact factors at the level of broad scientific areas (for example, Life Sciences or Engineering) are also considered inadequate, since each area includes several sub-fields with

important differences in IF values. To avoid these problems, the calculation of average IF at the level of disciplines is considered the most appropriate.

However, even at the level of disciplines or scientific categories, some problems may arise. The ISI categories sometimes comprise different subcategories with varying sizes or scientific habits (number of references per paper, half-life of references, and so on), leading to differences in the average IF. As an example, we can mention the difference we have found between Pharmacology journals and Pharmacy ones, both included under the ISI heading "Pharmacy and Pharmacology". In a previous study in Spain, two different research communities were identified: firstly the pharmacological teams from medical schools, who published in basic level journals with high IF, and secondly, the pharmacy teams, who published in more clinical journals with lower IF (*Bordons* and *Zulueta*, 1997) (Figure1).

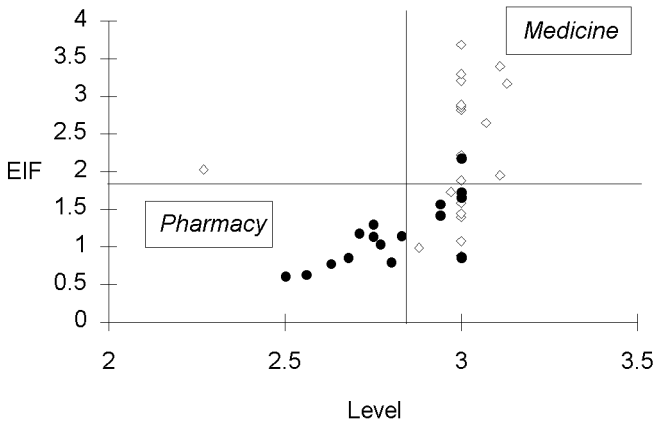

Figure 1. Distribution of university teams in Pharmacology & Pharmacy according to the average expected impact factor and average research level of their publications. (Horizontal and vertical lines show average values in the category. Level= research level according to the CHI classification of journals into research levels (*Noma*, 1986). EIF= expected impact factor.)

It is clear that this problem should be borne in mind during the planning and development of a bibliometric study where specific groupings of disciplines are needed, for example those requested by policy makers, financial agencies or any other party who demands the study.

International comparisons

The position of a given country in the international context is an interesting issue that can be analysed both from a quantitative and qualitative point of view. First, the number of publications of a country and its contribution to the total world can be obtained. Secondly, the impact of its production, preferably by scientific disciplines, can be measured through citation or impact factor measures.

In the case of Spain, its scientific production in the ISI databases has increased significantly in almost all disciplines over the last two decades. A clear upward trend in the use of international publication journals was observed for Spanish scientists in the recent past. In spite of the trend of Spanish scientists to publish in more visible journals, as has been reported in different disciplines (*Camí* et al., 1997), a lower increase in the real number of citations received by the documents was observed. The fact is that the number of citations received by documents from peripheral countries is frequently lower than that expected in accordance with the IF of the publication journal, as observed for Spanish Biomedicine (*Camí* et al., 1993). In the period 1995-1999, Spain exceeded the world average impact in only five out of 20 fields (ISI, 2001). The influence of sociological factors in the citation process may be partly responsible for this, since scientists prefer to cite documents from central countries, which are seen as being more reliable. A higher status is conferred on scientific knowledge generated in the central countries compared with that generated in peripheral countries (*Velho*, 1986). From this point of view, the study of the expected IF evolution over time may be preferable to citation counts for the monitoring of the international visibility of peripheral countries, since it involves the quality of publications and is less influenced by sociological factors.

An important aspect for peripheral countries is the low coverage of their national journals in the ISI databases. Two main consequences can be pointed out. The first concerns the quantity of the production of these countries which is frequently underestimated, since only the most internationally-oriented part is covered. But there is also a paradoxical effect. National journals of peripheral countries, when covered by ISI, are usually in the fourth quartile according to their IF (*Zitt* et al., 1997). Curiously, a positive national success such as the acceptance of a domestic journal into the SCI may show negative effects for the country's impact, since the average IF of the category can decrease, due to the low impact factor of its domestic journals. This effect was clearly shown in the case of the Spanish journal *Medicina Clínica*, included in the SCI as source journal since 1992. As a result, the scientific production of Spain in Internal Medicine showed an impressive increase from 1986-1989 to 1990-1993 (300%), but the

low IF of *Medicina Clínica*, especially the first year recorded, caused a decrease in the average IF of Spain in that field. It fell from 8.852 in the first period to 2.891 in the second, corresponding to a hypothetical journal changing from position 3 to position 10 in the ranking of journals in descending order of IF (*Camí* et al., 1997). Due to this observation, the use of a fixed set of core journals for international comparisons in bibliometric studies has been suggested by some authors (*Van Leeuwen* et al., 2000).

Regional comparisons

One of the main concerns of science policy managers is to be able to identify outstanding regions active in a specific discipline. With this aim, the total production and the average expected IF by discipline are used in our bibliometric studies to compare Spanish regions. Outstanding regions in a given discipline are identified according to their higher activity and higher average IF than the whole country in the specified discipline.

Two different indicators are used: the activity index and the relative impact factor. The activity index (AI) is the ratio between the share of a given field in the publication of a region and the share of the given field in the total country publications. An activity index higher than 1 indicates higher-than-average activity, whereas an index lower than 1 reflects lower-than- average activity. It enables us to identify the specialisation profile of regions. Similarly, the relative impact factor (RIF) of a certain region in a given discipline is calculated as the ratio between the average expected IF of the region's output and the average expected IF of the whole of Spain in the discipline. It may identify those regions that publish in "more visible" journals than the country as a whole.

Analyses of the activity of centres: inter-field comparisons

Bibliometric analyses enable us to assess the scientific performance of centres, at least the part reflected in publications, and to identify national centres of excellence. The activity and impact of a given centre in a specific discipline can be compared either with those of other centres in the same discipline or with the average values of the whole country in the given discipline through the AI and the RIF. This method allows us to identify centres of excellence in specific disciplines, or to identify the thematic strengths of a given centre. For example, in a recent study of the scientific production of the Spanish Research Council (CSIC) the categories in which this organisation obtained a

RIF over 1 were identified as CSIC strong areas. The categories in which CSIC was the most productive are shown in Table 1. It is interesting to note that CSIC published in higher impact factor journals than the total country in its most productive categories, that is, it obtained a RIF higher than 1 (*Gómez* et al., 2001).

Table 1. Distribution of Spanish CSIC production in its ten most productive categories (1997-1999)

Category	CSIC			Spain			CSIC/Spain	
	No. Doc.	%	IF	No. Doc.	%	IF	AI	RIF
Biochemistry & Mol.Biol.	1169	10.89	4.69	3319	6.67	3.80	1.63	1.23
Physical Chemistry	864	8.05	1.89	2613	5.25	1.76	1.53	1.07
Physics, Condensed Matter	653	6.08	1.72	1658	3.33	1.65	1.83	1.05
Materials Science	600	5.59	1.35	1455	2.92	1.25	1.91	1.08
Organic Chemistry	548	5.11	2.5	1913	3.84	2.47	1.33	1.01
Food Science & Technol.	548	5.11	1.21	1375	2.76	1.17	1.85	1.04
Plant Biology	514	4.79	1.91	1519	3.05	1.59	1.57	1.20
Physics	409	3.81	3.07	1627	3.27	2.68	1.17	1.15
Inorganic & Nuclear Chemistry	398	3.71	2.45	1374	2.76	2.22	1.34	1.10
Agriculture	398	3.71	1.1	937	1.88	1.08	1.97	1.02

Source: *Gómez* et al., (2001)

Moreover, the CSIC centres active in the category of Biochemistry and Molecular Biology were identified. A selection of the centres with the highest RIF is shown in Table 2. As we can see, all except one centre published in higher impact factor journals than the country average.

Table 2. Most active CSIC centres in the Biochemistry & Molecular Biology category in descending order of RIF (1997-99)

CENTRES	No. Doc.	Level	IF	RIF
C. NAL. BIOTECNOL. CSIC, MADRID	163	3.99	6.35	1.67
I. MICROB. BIOQ. CSIC-U. SALAMANCA	34	3.97	5.58	1.47
C. BIOL. MOL. CSIC-UAM, MADRID	221	3.99	5.25	1.38
I. PARASIT. L. NEYRA CSIC, GRANADA	25	3.91	5.02	1.32
C. INV. BIOLOGICAS CSIC, MADRID	154	3.98	4.99	1.31
I. BIOQ. VEG. FOT. CSIC-U. SEVILLA	33	4	4.81	1.27
I. BIOL. MOL. CEL. PLANT. CSIC-UPV	25	4	4.69	1.24
I. INV. BIOMEDICAS CSIC, MADRID	119	4	4.32	1.14
I. ESTRUCT. MATERIA CSIC, MADRID	32	4	4.29	1.13
I. QUIM. FIS. ROCASOL. CSIC, MADRID	33	4	4	1.05
C. INV. DESARR. CSIC, BARCELONA	121	3.94	3.67	0.97

Source: *Gómez* et al., (2001)
Note: only centres with more than 25 articles considered

In the case of multidisciplinary centres, whose activity is spread over a wide range of disciplines, inter-field impact comparisons are not directly possible due to the important differences in the range of variation of IF. To overcome the above-mentioned problem different standardisation methods have been described in the literature, from quartiles to other more sophisticated methods (*Moed* et al., 1998; *Solari* and *Magri*, 2000). In our studies we have introduced the normalised journal position (NJP) built upon the IF (*Bordons* and *Barrigón*, 1992). It considers, for a given discipline, the list of journals in descending order according to their IF. The NJP of a centre in a specific discipline, which ranges from zero to one, is the ratio of the ordinal position occupied by a hypothetical journal corresponding to the average IF of the centre's output divided by the total number of journals included in the list, substracted this value from 1. It provides a general profile of the impact of the centres' production in all the disciplines. Thus, the higher the NJP, the higher the position of the hypothetical journal in its subject category in descending order of IF. The most productive categories of a CSIC physics centre are shown in Table 3. Although the highest impact factor for this centre is found in Biochemistry and Molecular Biology, the use of the NJP indicator highlights the activity in other categories such as Condensed Matter Physics or Physics, where the highest NJP is obtained.

Table 3. Scientific production of the Instituto de Estructura de la Materia (CSIC) by categories in descending order of normalised journal position (1997-1999)

Category	No. Doc.	Level	IF	NJP	RIF
Condensed Matter Physics	32	3.9	2.25	0.90	1.37
Physics	49	4	3.63	0.89	1.36
Physics, Atomic Molecular & Chem.	53	4	2.29	0.84	0.96
Biochemistry & Molec. Biology	32	4	4.29	0.83	1.13
Polymer Science	53	3	1.29	0.82	0.97
Optics	10	3.2	1.61	0.79	1.21
Nuclear Physics	59	3.9	2.62	0.76	1.07
Applied Physics	10	3.1	1.44	0.71	0.91
Materials Science	13	2.2	0.80	0.70	0.64
Astronomy & Astrophysics	24	4	1.57	0.57	0.90
Spectroscopy	27	3.9	1.35	0.51	0.73
Physical Chemistry	43	3.8	1.18	0.46	0.67

Source: *Gómez* et al., (2000)
Note: only categories with more than 10 articles considered. Level= research level according to the CHI classification of journals into research levels (*Noma*, 1986).

Impact factor indicators can be combined with citation-based indicators in the assessment of centres: the number of citations received, the percentage of cited documents or the number of papers published in "top multidisciplinary" journals, such as *Nature*, *Science* or *PNAS*, are some of the indicators that can be used.

National journals

National journals of peripheral countries are hardly covered by ISI databases. However, they play an important role in the dissemination of research in the most locally-oriented areas, such as Earth Sciences or Clinical Medicine. In the analysis of these areas, it is considered convenient to complement data from ISI databases with data from national sources.

The Spanish database ICYT, which covers Spanish journals in science and technology, has been used in our studies dealing with the scientific production of Spain. However, there is no qualitative indicator like the JCR impact factor to assess prestige or quality of journals. It would be interesting to construct impact factor measures for these national journals not covered by JCR, but it is a very laborious and time-consuming task (*Sen* et al., 1989; *Stegmann*, 1999). A citation database of Spanish Internal Medicine journals was in fact created and the IF of these journals were calculated, but it was a short experience over a two-year period (*López Piñero* and *Terrada*, 1994).

Micro level analyses

Since the validity of bibliometric indicators decreases as the size of the analysed unit diminishes, the average expected IF of the production of a given author is not a reliable indicator (*Seglen*, 1992). However, this indicator may be more useful if applied to the whole production of medium/large size research teams. In our studies dealing with the analysis of research teams through bibliometric indicators, these teams are identified according to co-authorship in publications and are then described on the basis of their size, scientific production and international visibility. Top groups in a given discipline can be identified and described regarding their scientific output and IF of their publication journals, which has been described as being over-average (for example *Bordons* and *Zulueta*, 1997) (Table 4).

Table 4. Average impact factor of the scientific production of top teams vs. total field in two biomedical categories

	Pharmacology & Pharmacy (n=1770)	Cardiovascular System (n=376)
Top teams	1.88(0.93)	3.28(1.03)
Total field	1.68(1.34)	2.47(1.93)

Note: median(standard deviation)

The Spanish science policy managers use publications in international standard journals as a quality criterion to assess professional performance of scientists of the "hard" sciences. In Spain, research performance of scientists is assessed every six years by panels of experts in different areas. In each assessment, scientists are requested to submit their curricula and to indicate their five most important scientific contributions during the period under evaluation. The impact factor of the publication journals is one of the criteria used to support the quality of their publications together with citations received. Panels of experts in eleven broad areas are in charge of the research performance assessment. Although one would suppose that panels should include professionals from all the disciplines they are to evaluate, it is difficult to have specialists in all disciplines. Therefore, objective indicators such as impact factors play an important role in the evaluation process. Advantages and limitations of IF measures should be known not only by bibliometricians but also by researchers and policy managers.

Final remarks

Impact factor measures are widely used by librarians, editors, publishers and researchers. But perhaps the most important and recent use of impact factor is in the process of academic evaluation. Among the main advantages of IF measures we can mention that it is a quasi-qualitative indicator and is more immediately and easily obtained than citations. Moreover, it gives a visible form to the invisible (but tacitly accepted by scientists) hierarchy of scientific journals. It is used for the assessment of research performance of regions, centres, groups and even individual scientists.

However, the need to use IF measures carefully is widely recognised. We should bear in mind the limitations, such as:

– It is only available for SCI and SSCI journals. Due to the lower validity of citations in the Humanities, ISI does not calculate impact factors for journals in this area. Moreover, impact factors are more reliable in the hard than in the soft sciences.

– A fixed set of journals could be convenient for international analysis. Very few journals from peripheral countries are covered in SCI and SSCI. However, when domestic journals from these countries are covered, a decrease in the average IF of the country production is produced, since national journals usually show very low impact factors. This could influence time series data and should be taken into account by analysts.

– Calculation of IF for domestic journals not covered by ISI databases may be a useful way of complementing data from ISI. However, this is a very laborious, expensive and time-consuming task.

– The widespread use of IF measures within the research evaluation process has produced some negative effects. Abuse and incorrect use of IF measures are the underlying reasons. The priority of international vs. national journals in the agenda of scientists (with the corresponding impoverishment of the domestic journals); priority of international vs. national research subjects (particularly in peripheral countries) and a lesser consideration of “slow" evolving disciplines (in which low impact factors are the norm) are some of the consequences observed. Impact factor users should be aware of these effects and make sensible use of impact factor indicators.

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