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Providing impact: The distribution of JCR journals according to references they contribute to the 2-year and 5-year journal impact factors

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ABSTRACT

In general, scientometrics studies tend to focus on citations received *from* journals (incoming citations) and usually neglect references *to* journals (outgoing citations). The aim of this study is to suggest a new approach to the journal impact factor on a wider scale, i.e., from the viewpoint of citing journals. I studied how citations (references) given by JCR journals contribute to the 2-year and 5-year journal impact factors (JIF). To do so, data were obtained from the 2011 edition of JCR (Science Edition) available for universities in Spain, and the citing journal matrix for each journal was used. This matrix records the number of times articles published in other journals (cited journals) were cited in a given journal (citing journal) in 2011. The results showed that a set of 50 journals produced about 15% of all references that contributed to the 2-year JIF. Similarly, a set of 50 journals produced about 13% of all references that contributed to the 5-year JIF. A Bradford-like plot was obtained by plotting the cumulative number of references that contributed to the 2-year and 5-year JIF against the cumulative number of citing journals. The distribution of journals according to the number and percentage of references they contributed to the 2-year and 5-year JIF showed peaks. A rank-order distribution of references that contributed to the 2-year and 5 year JIF was obtained with a previously described empirical two-exponent equation. Based on the maximum contribution to the 2-year JIF of different 2-year rolling reference windows, the second rolling window (references to articles published 2 and 3 years before 2011) made the greatest contribution to impact in 41% of journals.

1. Introduction

Most methods used to study the relative influence of different journals are based on journal-to-journal citation transaction frequencies [Tijssen & Van Raan, 1990]. The journal impact factor (JIF) has become one of the most widely used scientometric indicators. This indicator is computed by Thomson–Reuters for each year (Y) according to the following equation [Glänzel & Moed, 2002]:

$$\text{JIF}(Y) = \frac{\text{Citations\_in\_}Y\text{\_to\_documents\_published\_in\_}Y1\text{\_and\_}Y2}{\text{Citable\_items\_published\_in\_}Y1\text{\_and\_}Y2}$$

In the previous equation, $Y1$ and $Y2$ are the two years before Y.

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There is a vast literature on the JIF, reviewed recently by Braun (2007), Bensman (2007) and Archambault and Larivière (2009). In 2012 the journal *Scientometrics* devoted an issue to the problems of JIFs and alternatives to this important indicator (Scientometrics, Vol. 92, issue 2, August: Special Discussion Issue on Journal Impact Factors). Below I summarize only research on the JIF that is relevant to the present study.

Since 2007, ISI-Thomson–Reuters published, in addition to the classical JIF computed with a 2-year citation window, a new JIF with a 5-year window. This new version of the older indicator addresses some of the criticisms against the short citation window [Jacso, 2009; Campanario, 2011]. However, the 5-year impact factor does not solve the problems that arise when journals from different fields of science are compared, because different fields have different citation practices. To address this problem, Dorta-González and Dorta-González (2013) proposed a clever idea: the 2-year maximum journal impact factor. This new kind of journal impact factor considers a 2-year rolling citation window to capture maximum impact, instead of a chronologically fixed 2-year window.

Some interesting properties of the distribution of JIF were discovered by Mansilla et al. These authors studied the rank-order distribution of JIFs and proposed the following empirical two-exponent equation for the rank-order behavior of JIFs:

$$\mathrm{JIF}(r) = K\frac{(N+1-r)^b}{r^a}$$

In the above equation, N is the number of cases, r is the rank position of a given JIF value, and K, b and a are the parameters to be obtained. Mansilla and colleagues found a very good fit to this equation [Mansilla, Köppen, Cocho, & Miramontes, 2007]. This empirical law also worked well for changes in JIF from one year to the following year [Campanario, 2010].

As Albarrán et al. acknowledge, most studies of citation analysis deal with citations received, i.e., incoming citations [Albarrán, Crespo, Ortuño, & Ruiz-Castillo, 2011]. Citations given (references, outgoing citations) are, in general, neglected in scientometrics studies. Below I review the scarce literature found on this topic.

Many years ago, Eugene Garfield noted that a small group of 250 journals provided almost half of the 3.85 million references processed for the SCI in 1969. This was one of the reasons why the JCR has been very selective [Garfield, 1972]. Albarrán and Ruiz-Castillo (2011) studied reference distributions with the characteristic scores and scales (CSS) technique, and estimated power laws with maximum likelihood techniques [Albarrán & Ruiz-Castillo, 2011]. In a follow-up study, Albarrán et al. studied reference and citation distributions in journals, and discovered that their characteristics differed considerably across sub-fields. However, when analyzed with the CCS technique, the shape of these distributions in three broad categories of articles was similar. Reference distributions were mildly skewed [Albarrán et al., 2011].

Didegah et al. undertook an international comparison of journal publishing and citing behaviors. They studied documents and their references indexed in Web of Science (WoS) in the period 2000–2009, and compared journal publishing behaviors against journal citing behaviors by scientists from different countries [Didegah, Thelwall, & Gazni, 2012]. In a sample of economics journals, Frandsen presented a method of citation analysis based on multiple linear regression for both cited and citing journals. He found that for the set of journals studied, citations were to a large extent self-supplied. However, his analysis included only a subset of journals in the field of economics [Frandsen, 2005].

Liang and Rousseau proposed an indicator framework based on references instead of citations. They suggested the use of a reference factor and even a reference-based h-index [Liang & Rousseau, 2010a]. Similarly, Nicolaisen and Frandsen, based on a previous study by [Yanovsky, 1981], introduced the reference return ratio. This new journal impact measure is based on references as bibliographic investments and citations as returns. They studied the relationship between the reference return ratio and the JIF, and found that the two measures were strongly related [Nicolaisen & Frandsen, 2008].

Using an area of astrophysics research as the data source, Bakdi applied logistic regression to examine the extent to which the characteristics of both potentially citing and potentially cited papers influenced the probability that a citation existed between the papers [Baldi, 1998]. As in other examples noted here, this study used data from only a single field of research. In a recent study, Bornmann and Marx suggested a new perspective in evaluative bibliometrics using references as source of a cited reference analysis. This approach starts by selecting all papers dealing with a given topic or field. Next, all cited references from the selected papers are extracted. Then, they analyze which papers, scientists, and journals have been cited most often [Bornmann & Marx, 2013].

Other authors have also used references in scientometrics studies, or suggested different ways in which references could be used [Evans, Hopkins, & Kaube, 2012; Huang, Andrews, & Tang, 2012; Liang & Rousseau, 2010b; Moed, 2010; Ruiz-Castillo, 2012; Tijssen & Van Raan, 1990; Zitt & Small, 2008; Zitt, 2011].

Despite the research summarized above, there appear to be no large-scale studies of the JIF that have focused on citing journals. Researchers tend to study the JIF from the viewpoint of cited journals (i.e., the journals that receive citations, and thus receive impact). However, most JCR journals cite other journals. These references contribute (when the window is the appropriate) to the journals' JIF. For example, as seen in the Table 1 below, the journal *Hormone Research in Paediatrics* contributed to other journals' 2011 JIF with 214 references to items published in 2010 and 335 references to items published in 2009. These references represent the impact "provided" by *Hormone Research in Paediatrics* and merit a more in-depth analysis. This study was designed in an attempt to shift the focus of research on JIFs from cited to citing journals.

Table 1
Journal *Hormone Research in Paediatrics*, first row of the citing journal matrix.

2011 JCR Science Edition
Citing Journal: Hormone Research in Paediatrics
Number of times articles published in journals below (in years below) were cited in HORM RES PAEDIAT in 2011

	Cited year											
	All years	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	Rest
All journals	4859	36	214	335	395	375	341	280	290	267	251	2075

The variables used were
(a) NRefJIF2, defined as the outgoing citations (references) in 2011 from a given citing journal to items published in 2010 and 2009.
(b) NRefJIF5, defined as the outgoing citations (references) in 2011 from a given citing journal to items published in 2010–2006.
(c) %RefJIF2, defined as NRefJIF2 divided by the total number of outgoing citations (references) in 2011 from a given citing journal.
(d) %RefJIF5, defined as NRefJIF5 divided by the total number of outgoing citations (references) in 2011 from a given citing journal.

2. Objectives

In light of the above, I set out to present a new approach to large-scale studies of the JIF from the viewpoint of citing journal, i.e., journals that provide impact by means of the references in the articles they publish. This study thus attempts to address the problem of the impact given, instead of the usual problem in scientometrics of the impact received. The specific goals of this study are:

a) to determine the distribution of JCR journals according to the citations they contribute (references) to the 2-year and 5 year JIF.
b) to determine whether previous models used to study the distribution of impact received are useful for attempts to study the impact given.

3. Data and method

The data for this study were obtained from the 2011 edition of JCR (Science Edition) available for universities in Spain. For each journal I used the citing journal matrix. This matrix is available on each journal's page in JCR and records the number of times articles published in other journals (cited journals) were cited in a given journal (citing journal) in 2011. In addition, this matrix records the total number of references made to all cited journals (included in JCR or not) in a given year (i.e., 2011) and in the previous 9 years from 2010 to 2002 (see Table 1). I used these data to calculate the number of citations (references) that each citing journal contributed to the impact of other journals.

For example, in the journal *Hormone Research in Paediatrics* (see Table 1), NRefJIF2 = 549, %RefJIF2 = 11.3, NRefJIF5 = 1660 and %RefJIF5 = 34.2.

I calculated descriptive statistics for the distribution of journals according to these variables. In addition, I studied the rank-order distribution of references that contributed to the 2-year and 5-year JIF, using the empirical equation proposed by Mansilla et al. (2007). I also calculated the contribution of each citing journal to a rolling JIF obtained with the approach used by Dorta-González and Dorta-González (2013). This rolling JIF was computed as follow: $R1$ was obtained by adding the references given in 2011 to items published in 2010 and 2009. Thus, $R1$ contains the references that contribute to the traditional 2-year JIF window. $R2$ contains the references given to papers published in 2009–2008, that is, 2 and 3 years before 2011, and so on. For example, as shown in the box for the journal *Hormone Research in Paediatrics*, $R1 = 549$, $R2 = 730$, $R3 = 770$, $R4 = 716$, $R5 = 621$, $R6 = 570$, $R7 = 557$ and $R8 = 518$. For each journal I identified its maximum R, i.e., the R corresponding to the 2-year period that contributed the greatest number of references. For example, in the journal *Hormone Research in Paediatrics* maximum R is $R3$.

4. Results and discussion

In the set of 8336 journals included in JCR, 218 journals did not contribute any references to the 2-year or 5-year JIF. In fact, 211 of these journals did not cite any items at all, 5 journals had only 1 reference to items published in 2011, and 2 journals had only 3 references to items published in 2011. All these journals were deleted from the master file. Thus, the final set used in the analysis consisted of 8118 citing journals.

Table 2 shows the 50 journals that contributed the most references to the 2-year and 5-year JIF. This set of 50 journals (0.62% of the entire set) produced about 15% of all references that contributed to the 2-year JIF. Similarly, another set of 50 journals provided about 13% of all references that contributed to the 5-year JIF. A total of 44 journals are included in both sets. There can be little doubt that these journals are influential contributors to other journals' JIFs.

The distribution of the cumulative references in Table 2 suggests a Bradford-type law. Fig. 1 plots the cumulative percentage of references against the cumulative number of journals for both 2-year and 5-year JIF (note that logarithmic scales are used in both axes). The pattern resembles the typical Bradford-type distribution [Rousseau, 1994].

Table 2
List of the 50 citing journals that contributed the most references to the 2-year (left) and 5-year (right) JIF. NRefJIF2: number of references given in 2011 to items published in 2010–2009.

Citing	NRefJIF2	%RefJIF2	Cum %RefJIF2	Citing	NRefJIF5	%RefJIF5	Cum %RefJIF5
PLOS ONE	116563	1.74	1.74	PLOS ONE	275475	1.68	1.68
PHYS REV B	44990	0.67	2.42	PHYS REV B	95511	0.58	2.26
J BIOL CHEM	33488	0.50	2.92	J BIOL CHEM	84390	0.51	2.77
J AM CHEM SOC	33131	0.50	3.41	J AM CHEM SOC	69502	0.42	3.20
ASTROPHYS J	30053	0.45	3.86	P NATL ACAD SCI USA	67020	0.41	3.61
P NATL ACAD SCI USA	29588	0.44	4.31	J PHYS CHEM C	65312	0.40	4.00
CHEM COMMUN	29366	0.44	4.75	ASTROPHYS J	63634	0.39	4.39
J PHYS CHEM C	29217	0.44	5.18	J MATER CHEM	60697	0.37	4.76
J MATER CHEM	28591	0.43	5.61	CHEM COMMUN	58870	0.36	5.12
PHYS REV D	27783	0.42	6.03	MON NOT R ASTRON SOC	55546	0.34	5.46
MON NOT R ASTRON SOC	25939	0.39	6.41	ANGEW CHEM INT EDIT	54600	0.33	5.79
ANGEW CHEM INT EDIT	25837	0.39	6.80	PHYS REV D	53673	0.33	6.12
CHEM-EUR J	21530	0.32	7.12	J APPL PHYS	49311	0.30	6.42
APPL PHYS LETT	20813	0.31	7.43	CHEM-BIOL INTERACT	48672	0.30	6.72
J APPL PHYS	20740	0.31	7.74	J GEOPHYS RES	46980	0.29	7.00
PHYS CHEM CHEM PHYS	20146	0.30	8.05	PHYS CHEM CHEM PHYS	46669	0.28	7.29
J GEOPHYS RES	19101	0.29	8.33	APPL PHYS LETT	43005	0.26	7.55
PHYS REV LETT	18961	0.28	8.62	ASTRON ASTROPHYS	40557	0.25	7.80
ASTRON ASTROPHYS	18759	0.28	8.90	J CHEM PHYS	39410	0.24	8.04
PHYS REV A	17209	0.26	9.15	PHYS REV LETT	38040	0.23	8.27
OPT EXPRESS	17111	0.26	9.41	J NEUROSCI	37562	0.23	8.50
J CHEM PHYS	16764	0.25	9.66	PHYS REV A	36365	0.22	8.72
J HIGH ENERGY PHYS	16576	0.25	9.91	OPT EXPRESS	35395	0.22	8.93
J NEUROSCI	15448	0.23	10.14	LANGMUIR	35213	0.21	9.15
ORG LETT	15300	0.23	10.37	BLOOD	33790	0.21	9.35
LANGMUIR	15247	0.23	10.60	DALTON T	33529	0.20	9.56
BLOOD	14772	0.22	10.82	INORG CHEM	31557	0.19	9.75
DALTON T	14495	0.22	11.03	J IMMUNOL	31516	0.19	9.94
ACS NANO	14068	0.21	11.25	ORG LETT	31193	0.19	10.13
INORG CHEM	13688	0.20	11.45	J HIGH ENERGY PHYS	30904	0.19	10.32
ANAL CHEM	13494	0.20	11.65	J PHYS CHEM B	30287	0.18	10.51
J ALLOY COMPD	13090	0.20	11.85	INT J HYDROGEN ENERG	29528	0.18	10.69
INT J HYDROGEN ENERG	12841	0.19	12.04	ACS NANO	28691	0.17	10.86
J IMMUNOL	12484	0.19	12.23	J VIROL	28240	0.17	11.03
J PHYS CHEM B	12327	0.18	12.41	PHYS REV E	27701	0.17	11.20
PHYS REV E	12108	0.18	12.59	SOFT MATTER	27442	0.17	11.37
SOFT MATTER	12023	0.18	12.77	J ORG CHEM	26614	0.16	11.53
J VIROL	11925	0.18	12.95	ANAL CHEM	26510	0.16	11.69
BIORESOURCE TECHNOL	11693	0.17	13.13	J ALLOY COMPD	26335	0.16	11.85
J ORG CHEM	11691	0.17	13.30	NEUROL ASIA	25115	0.15	12.01
ENVIRON SCI TECHNOL	11087	0.17	13.47	ENVIRON TECHNOL	24940	0.15	12.16
VACCINE	10800	0.16	13.63	J HAZARD MATER	24871	0.15	12.31
ADV MATER	10700	0.16	13.79	BIORESOURCE TECHNOL	24856	0.15	12.46
NUCLEIC ACIDS RES	10481	0.16	13.94	NUCLEIC ACIDS RES	24617	0.15	12.61
MACROMOLECULES	10391	0.16	14.10	J PHYS CHEM A	24568	0.15	12.76
J PHYS CHEM A	10244	0.15	14.25	CHEM REV	24553	0.15	12.91
J HAZARD MATER	10220	0.15	14.41	ELECTROMAGN BIOL MED	23631	0.14	13.05
BIOMATERIALS	10153	0.15	14.56	MACROMOLECULES	23240	0.14	13.20
ELECTROCHIM ACTA	10053	0.15	14.71	CURR MED CHEM	22850	0.14	13.34
TETRAHEDRON LETT	10002	0.15	14.86	TETRAHEDRON LETT	22689	0.14	13.47

NRefJIF5: number of references given in 2011 to items published in 2010–2006.
%RefJIF2: NRefJIF2 divided by the total number of references given by all JCR journals to items published in 2010–2009.
%RefJIF5: NRefJIF5 divided by the total number of references given by all JCR journals to items published in 2010–2006.

Fig. 2 shows the distribution of all citing journals according to the number of references they contributed to the 2-year and 5-year JIF. Both distributions show peaks at about 100–200 references (2-year JIF) and about 200–400 references (5-year JIF). The tails of both distributions are very similar.

The references in citing journals in 2011 are to items published in different years (see box). Thus, it is of interest to study the distribution of journals according to the fraction of all references that contributed to the 2-year and 5-year JIF. Obviously, when a citing journal often cites papers published in recent years, this suggests that the research it publishes is evolving quickly and is heavily dependent on the latest scientific information and results. Fig. 3 shows the distribution of citing journals according to the percentage of references they contributed to the 2-year and the 5-year JIF. Again, both distributions have peaks which appear at about 12% for the 2-year JIF and about 38% for the 5-year JIF. The distribution of journals according to %RefJIF5 is wider than the distribution according to %RefJIF2. About 66% of journals gave between 8% and 16% of their references to items published in the years that contribute to the 2-year JIF. In contrast, about 67% of journals

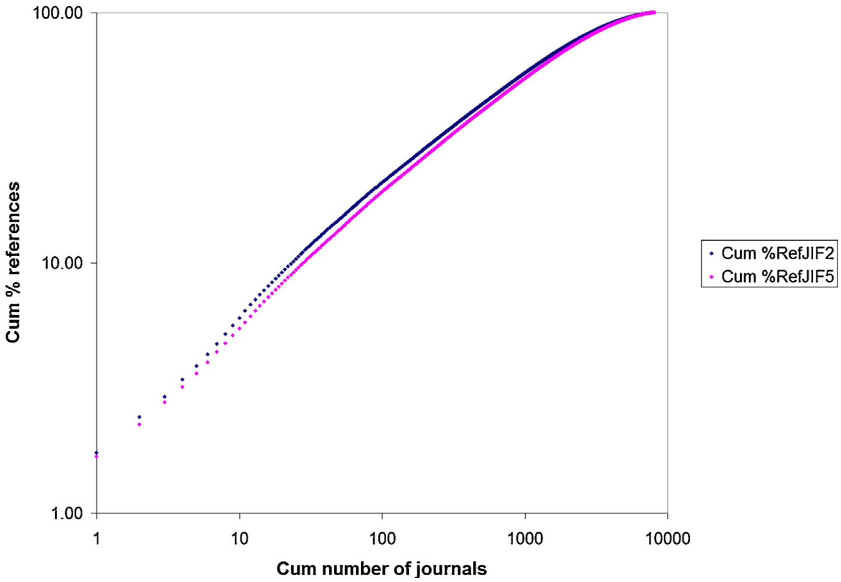

Fig. 1. Cumulative percentage of references given by all citing journals included in the set versus cumulative number of citing journals. Note that logarithmic scales are used in both axes.

(a similar percentage) gave between 30% and 48% of their references to items published in years that contribute to the 5-year JIF.

Fig. 4 shows the distribution of citing journals according to the fraction of the number of references that contributed to the 2-year JIF divided by the number of references that contributed to the 5-year JIF, expressed as a percentage:

$$\text{Fraction} = \frac{\text{NRefJIF2}}{\text{NRefJIF5}} \times 100$$

The distribution is symmetrical around a peak at about 40%. In about 76% of journals, this fraction comprised between 32% and 48%.

Figs. 5 and 6 show the rank-order distribution of references that contributed to the 2-year and 5-year JIF. These figures were obtained by plotting the value against rank, as in previous studies [Campanario, 2010]. For example, as shown in Table 2, the journal PLOS ONE provided 116563 references that contributed to the 2-year JIF. This number of references places this journal at the top of the ranking. The journal PHYS REV B provided 44,990 references that contributed to the 2-year JIF, and

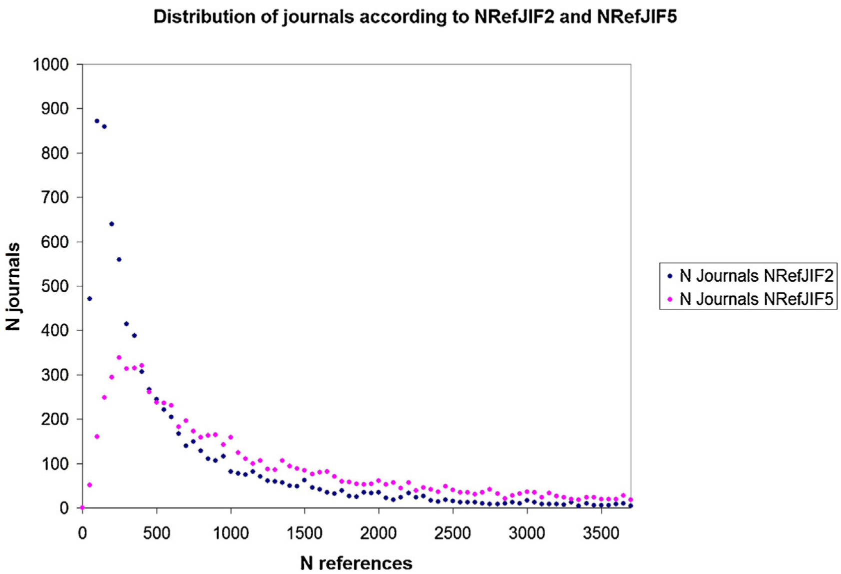

Fig. 2. Distribution of citing journals according the number of references contributing to the 2-year and 5-year JIF. Only journals with 3700 references or less were included (96.8% of journals for the 2-year JIF plot, and 87.3% of journals for the 5-year JIF plot)

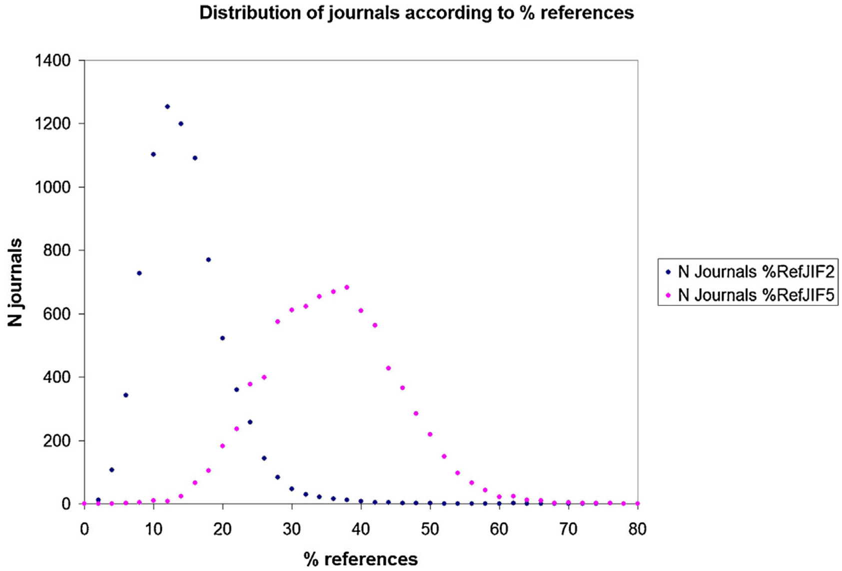

Fig. 3. Distribution of citing journals according to %RefJIF2 (the percentage of references contributing to the 2-year JIF) and %RefJIF5 (the percentage of references contributing to the 5-year JIF).

thus occupies the second position in the ranking. I fitted the data to the model of Mansilla et al. (2007). I calculated the value of the parameters with the linear least squares method. Previously, I transformed the equations using logarithms to yield: $\log(\text{NRefJIF2}) = \log(K) + b\log(N+1-r) - a\log(r)$. The parameters obtained in these computations were $K = 59.72$, $a = 0.89$ and $b = -0.47$ for 2-year JIF (NRefJIF2), and $K = 173.09$, $a = 0.84$ and $b = -0.51$ for 5-year JIF (NRefJIF5).

Fig. 7 plots the variable %RefJIF5 against %RefJIF2. The relationship is slightly curvilinear.

Table 3 shows the distribution of journals according their maximum R calculated as explained above with an approach similar to that used by Dorta-González and Dorta-González (2013). In 2011 about 41% of journals gave the greatest number of references to items published in 2009 and 2008 ($R2$). This is not the usual window used to compute the JIF. In fact, only about 18% of citing journals provided the maximum number of references to items published in the years used by ISI-Thomson–Reuters to compute the JIF. This finding is potentially relevant to discussions of the optimum window to compute the JIF.

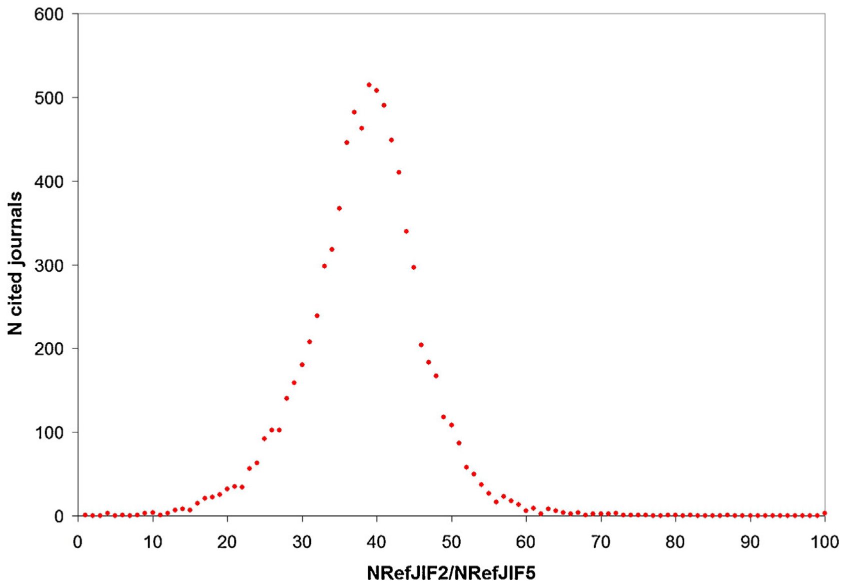

Fig. 4. Distribution of citing journals according to the number of references that contribute to the 2-year JIF divided by the number of references that contribute to the 5-year JIF, expressed as a percentage

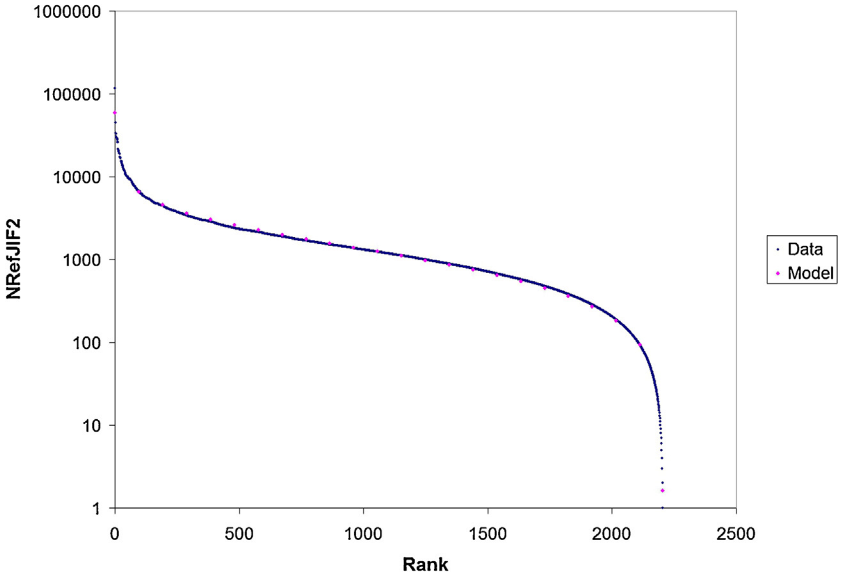

Fig. 5. Rank-order distribution of the references that contribute to the 2-year JIF. Note that a logarithmic scale is used in the *y*-axis.

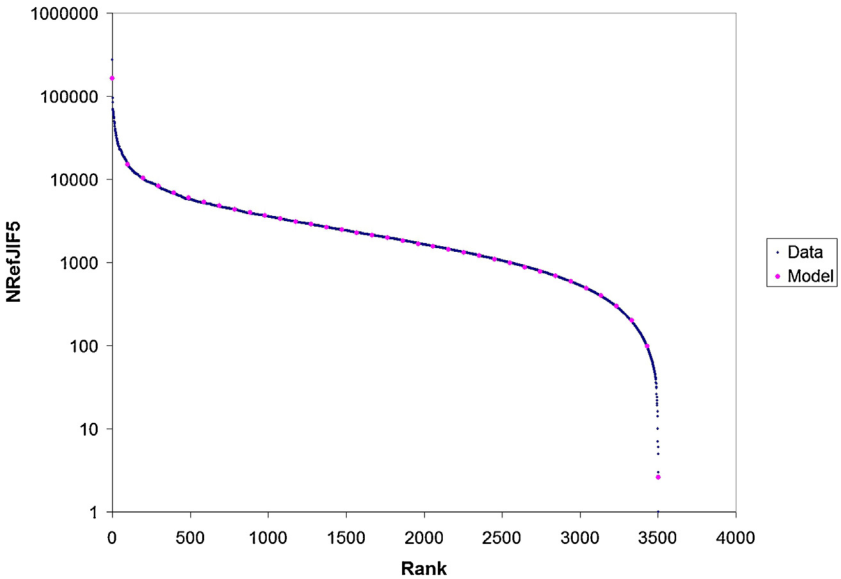

Fig. 6. Rank-order distribution of the references that contribute to the 5-year JIF. Note that a logarithmic scale is used in the *y*-axis.

Table 3
Distribution of journals according to their maximum *R*.

R	*N* journals	%
1	1475	18.2
2	3361	41.4
3	1651	20.3
4	903	11.1
5	391	4.8
6	190	2.3
7	96	1.2
8	51	0.6
Total	8118	100.0

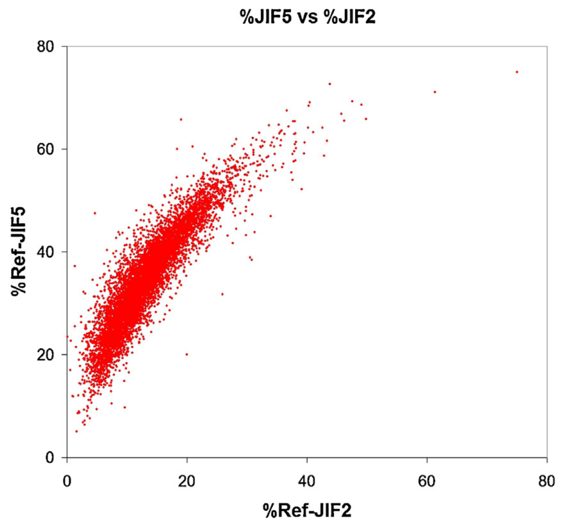

Fig. 7. Variable %RefJIF5 versus variable %RefJIF2.

5. Conclusions

In general, there is a lack of scientometric studies that use outgoing citations as the source of data. Researchers usually tend to focus on incoming citations received by authors, articles, journals, or other units of analysis. However, obviously no citation is possible without a reference. In this study I used references provided by the citing journal as the primary data. This approach has been mostly unexplored and is open to analysis by researchers who wish to try new challenges. Below I summarize the main conclusions.

The results obtained in this study showed that a set of 50 journals (0.6% of the entire set) produced about 15% of all references that contributed to the 2-year JIF. Similarly, a set of 50 journals produced about 13% of all references that contributed to the 5-year JIF. These sets overlapped to a great degree. In fact, in a previous study we found many similarities between 2-year-JIF and 5-year-JIF [Campanario, 2011].

We obtained a Bradford-like curve when the cumulative number of references was plotted against the cumulative number of journals. Bradford's law can be considered one of the most important laws in bibliometrics. Some researchers have tried to ascertain the exact form of Bradford's distribution. For us, the exact shape of the curve or the precise equation that describes Bradford's distribution are not the most relevant issues. The most interesting result is the general trend in the Bradford-like distributions we found: few journals account for many references.

A problem with many studies that have attempted to confirm the validity of Bradford's law is that the results are not neutral when the law is used as a tool to identify core information sources in a given subject. Instead, the results will depend on how the "subject" is defined or operationalized [Nicolaisen & Hjørland, 2007]. We made no attempt here to define "subject" because all journals were included as data sources. A potentially interesting study would be to compare the validity of Bradford's law in references that contribute to the JIF across different JCR fields or groups. The results of such a study could be used to optimize library collections; in addition, the results could identify journals in each JCR field as mainly providers of impact or as mainly impact receivers.

The distribution of journals according to the number and percentage of references they contribute to the 2-year and 5-year JIFs showed peaks. Both distributions were similar, although the curve for the 5-year JIF was wider – a feature which was unsurprising. The main implication of the results for the 2-year JIF is that only a few journals showed a pattern whereby papers published in the previous 2 years were cited much more than papers published 3 or more years before. Many studies have supported the validity of the 2-year window to compute the JIF. Until now, criticisms tended to focus on the ability of the 2-year window to capture a relevant share of citations received. Our results suggest that for most journals, this window is not appropriate either for measuring the impact of outgoing citations, i.e., the impact given to other journals.

The distribution of citing journals according to the number of references that contributed to the 2-year JIF divided by the number of references that contributed to the 5-year JIF (Fig. 4) could be used to classify citing journals according to their changing dependence on cited journals with time. The peak value appeared at approximately 40%. Journals to the right of the peak (for example, 50%) depend on (i.e., cite) more recent documents more often than older documents. These journals publish papers in rapidly evolving research areas. In contrast, journals to the left of the peak are more likely to cite older items and to publish research in more slowly evolving areas. As noted above, a potentially informative topic for further research is the comparison of these distributions across different fields.

We also calculated the maximum 2-year contribution to the 2-year JIF on the basis of 2-year rolling reference windows according to the approach suggested by Dorta-González and Dorta-González (2013). These calculations showed that in 41%

of journals, the greatest numbers of references were made to items published during the second rolling window (*R*2, 2 and 3 years before 2011). This finding is again of potential interest for debates regarding the best sampling window to compute the JIF, since the *R*2 window contains only one of the 2 years used by ISI-Thomson–Reuters to obtain the traditional 2-year JIF. Note, however, that Dorta-González and Dorta González studied incoming citations, not outgoing citations. It would be interesting to systematically compare rolling windows for both outgoing references and incoming citations. In some fields the contributions made to other journals' JIFs (outgoing references) may differ from the citations received from other journals, and that contribute to the index journal's JIF.

Another conclusion is that the rank-order distribution of references that contribute to the 2-year and 5-year JIF showed a very good fit to the law suggested by Mansilla et al., and tested previously with JIFs and changes in JIFs [Campanario, 2010; Mansilla et al., 2007]. There appear to be many data sets that follow the rank-order distribution reported by Mansilla et al. [Naumis & Cocho, 2008; Martinez-Mekler et al., 2009]. This law has interesting implications in the field of scientometrics. In most cases, when real data are used, power laws hold only for an intermediate range of values, whereas the tails of the distributions tend to deviate from the values expected according to the power law. Martinez-Mekler et al. suggested that the two parameter law incorporates the product of two power laws defined over the complete data set. One of these power laws is measured from left to right, and the other from right to left [Martinez-Mekler et al., 2009]. Egghe and Waltman studied the shape of rank-frequency distributions both theoretically and empirically. They found that for most fields, the rank-frequency distributions of the number of articles and journal impact factors were S-shaped. However, the concave part of the curve was sometimes very small [Egghe & Waltman, 2011]. This was not the case for the distributions studied here: both were clearly S-shaped and thus confirmed the validity of the original beta law equation.

Some limitations of this study should be noted. One of the original purposes of the JIF was to reflect the size of journals. As Bensman pointed out, the JIF no longer comprises the total number of citations to a given scientific article. Accordingly, the JIF is to be used only for comparative purposes. Garfield explicitly rejected size as a component of "importance" [Bensman, 2007]. However, our initial study made no attempt to consider the size of the citing journals, but aimed only to examine the distribution of their outgoing citations.

Some potential extensions of this study may be worth pursuing. Scientometric indicators used previously could be tested with references instead of citations as the data source, for example the h-index. These efforts may open new avenues of both theoretical and applied research. As Liang and Rousseau noted, basically everything that has been studied for citations can also be studied for references [Liang & Rousseau, 2010a].

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