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A new approach to the metric of journals' scientific prestige: The SJR indicator

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ABSTRACT

A size-independent indicator of journals' scientific prestige, the SCImago Journal Rank (SJR) indicator, is proposed that ranks scholarly journals based on citation weighting schemes and eigenvector centrality. It is designed for use with complex and heterogeneous citation networks such as Scopus. Its computation method is described, and the results of its implementation on the Scopus 2007 dataset is compared with those of an *ad hoc* Journal Impact Factor, JIF(3y), both generally and within specific scientific areas. Both the SJR indicator and the JIF distributions were found to fit well to a logarithmic law. While the two metrics were strongly correlated, there were also major changes in rank. In addition, two general characteristics were observed. On the one hand, journals' scientific influence or prestige as computed by the SJR indicator tended to be concentrated in fewer journals than the quantity of citation measured by JIF(3y). And on the other, the distance between the top-ranked journals and the rest tended to be greater in the SJR ranking than in that of the JIF(3y), while the separation between the middle and lower ranked journals tended to be smaller.

1. Introduction

Citation analyses play an essential role in research evaluation systems, with their results being widely applied as complements to expert review.

The citedness of a scientific agent has for decades been regarded as an indicator of its scientific impact, and used to position it relative to other agents in the web of scholarly communications. In particular, various metrics based on citation counts have been developed to evaluate the impact of scholarly journals, one of which, the Impact Factor, has been extensively used for more than 40 years (Garfield, 2006).

However, recently a new research trend has emerged aimed at developing impact metrics that consider not only the raw number of citations received by a scientific agent, but also the importance or influence of the actors who issue those citations (Bergstrom, 2007; Bollen, Rodríguez & van de Sompel, 2006; Ma et al., 2008; Palacios-Huerta & Volij, 2004). These new metrics represent scientific impact as a function not of just the quantity of citations received but of a combination of the quantity and the quality.

The essential idea underlying the application of these arguments to the evaluation of scholarly journals is to assign weights to bibliographic citations based on the importance of the journals that issued them, so that citations issued by more

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important journals will be more valuable than those issued by less important ones. This "importance" will be computed recursively, i.e., the important journals will be those which in turn receive many citations from other important journals.

The first proposal in this sense in the field of Information Science was put forward by Pinski and Narin (1976), with a metric they called "Journal Influence". Their proposed algorithm iterates the transfer of "prestige" from one journal to another until a steady-state solution is reached, whose values reflect the journals' scientific influence. The "Journal Influence" indicator is a variant of the eigenvector centrality measure (Bonacich, 1987), with its calculation belonging to the group of eigenvector centrality methods in the domain of Network Theory. However, Pinsky and Narin's method presented problems that were essentially related to the topological structure of the citation network.

With the arrival of the PageRank algorithm (Page et al., 1998) developed by the creators of Google, one had a computational model that resolved the aforementioned structure-related problems (Brin & Page, 1998; Page, 2001). Inspired in the Perron–Frobenius theorem, this algorithm modifies the network's structure by redefining the meaning of the connections between the nodes that together conform the network's graph. In particular, it defines connections (citations) as the probability of going from one node to another, and, using a random-walker probabilistic model, transforms the citation network into a strongly connected graph, i.e., a network in which, given any two nodes, there is always some path to get from one to the other.

Applied to journal citation networks, this new model means that each connection between nodes (journals) represents the probability that a researcher, in documenting his or her research, goes from one journal to another by selecting a random reference in a research article of the citing journal. The values obtained at the end of the process represent a "random research walk" which starts from a random journal to end in another after following an infinite process of selecting random references in research articles. Also, to connect nodes (journals) between which there exist no paths established by means of citation relationships, a random jump factor is added to represent the probability that the researcher chooses a journal by means other than following the references of research articles.

The method also defines an iterative algorithm that starts from certain initial pre-established values, and computes values of centrality until a steady-state solution is reached. The importance (prestige) of the nodes is redistributed at each iteration in terms of their connections with other nodes. The general formula used in this process is:

$$PR(Node_i, it_k) = \frac{1-\lambda}{N} + \lambda \sum_{j=1}^{N} (Connection_{(i,j)}) \cdot PR(Node_j, it_{k-1})$$

where the importance of node i in iteration k is set by the sum of the relative importance transferred by all the i-connected nodes. The amount of importance transferred by node j to node i is weighted by the strength of the connection between them, which is the fraction of references in node j in the year being considered that are to node i. The proportion of prestige that is transferred by means of the connections is modulated by means of the parameter λ which can take values in the range 0–1. The random jump factor, represented by the first term in the formula, is included to ensure convergence of the algorithm.

We introduce here a new indicator called SCImago Journal Rank (SJR) indicator, that indicates what can be denominated as journal's influence or prestige (Bollen et al., 2006), that belongs to this new family of indicators based on eigenvector centrality. The SJR indicator is a size-independent metric aimed at measuring the current "average prestige per paper" of journals for use in research evaluation processes. It has already been studied as a tool for evaluating the journals in the Scopus database (Guz & Rushchitsky, 2009), compared with the Thomson Scientific Impact Factor (Falagas, Kouranos, Arencibia-Jorge, & Karageorgopoulos, 2008), and shown to constitute a good alternative for journal evaluation (Leydesdorff, 2009). In studying both bibliometric and usage indicators, Bollen, van de Sompel, Hagberg, and Chute (2009) grouped the Impact Factor and the SCImago Journal Rank together, while clustering the Journal PageRank measure together with other "betweenness" centrality indicators. This was because the former are size-independent indicators rather than because they measure popularity as such.

In the following sections, we shall describe the methodological aspects of the development of the SJR indicator, and the results obtained with its implementation on Elsevier's Scopus database, for which the data were obtained from SCImago Journal & Country Rank website, an open access informetric directory with more than 17 000 research journals and other periodical publications (2009).

2. Data

We used Scopus as the data source for the development of the SJR indicator because it best represents the overall structure of world science at a global scale. Scopus is the world's largest scientific database if we look at the period 2000–2009. It covers most of the journals included in the Thomson Reuters Web of Science (WoS) and more (Leydesdorff, Moya-Anegón & Guerrero-Bote, in press; Moya-Anegón et al., 2007). Also, despite its only relatively recent launch in 2004, there are already various studies of its structure and coverage (Bar-Ilan, 2008; Jacso, 2009; Laguardia, 2005). Our choice of database reflects the consideration of four criteria that are of great importance in the computation of any bibliometric indicator. These are:

1. Journal coverage.
2. Relationship between primary (citable items) and total production in each journal of the database.
3. Assignment criteria for types of documents.
4. Accuracy of the linkage between references and source records.

Only documents published in 2007 included in the Scopus database were used for the main part of the study (in number, 1 624 540). All their references to documents present in the database in previous years were retrieved (in number, 22 934 115). The total number of references found in the documents of 2007 (i.e., references both inside and outside the database) was 44 014 140.

Documents are classified by area and category. There are 295 specific subject areas grouped into 26 subject areas. In addition, there is the General subject area containing multidisciplinary journals, such as Nature or Science. The subject areas are grouped into four categories on the Scopus "Basic Search" page (see the Scopus website, www.scopus.com, visited on 7 August 2009).

The four Scopus categories are:

- Life Sciences (>4300 titles): *Agricultural* & *Biological Sciences*; *Biochemistry, Genetics* & *Molecular Biology*; *Immunology* & *Microbiology*; *Neuroscience, Pharmacology, Toxicology* & *Pharmaceutics*.
- *Physical Sciences (>7200 titles): Chemical Engineering*; *Chemistry*; *Computer Science*; *Earth* & *Planetary Science*; *Energy*; *Engineering*; *Environmental Science*; *Materials Science*; *Mathematics*; *Physics* & *Astronomy*.
- Social Sciences (>5300 titles): *Arts* & *Humanities*; *Business, Management* & *Accounting*; *Decision Sciences*; *Economics, Econometrics and Finance*; *Psychology*; *Social Sciences*.
- Health Sciences (>6800 titles, including 100% coverage of Medline titles): *Medicine*; *Nursing*; *Veterinary*; *Dentistry*; *Health Professions*.

3. Method

The SJR indicator is computed over a journal citation network where the nodes represent the scholarly journals in the database and the directed connections among the nodes the citation relationships among such journals. In our approach in particular, a directed connection between two journals is a normalized value of the number of references that the transferring journal makes to the recipient journal. The normalization factor used is the total number of references of the transferring journal in the year under study. The citation time window is set to three years, so that journal prestige is distributed among the references issued in the year under study directed to the papers published in the three previous years. The three-year citation window was chosen as the shortest one that embraces citation peaks of all the subject areas in Scopus as shown in Fig. 1.

Next, in order to prevent excessive journal self-citation, the number of references that a journal may direct to itself is limited to a maximum 33% of its total references.

The computation is carried out using an iterative scheme that distributes prestige values among the journals until a steady-state solution is reached. The SJR algorithm begins by assigning an identical amount of prestige to each journal. Next, this prestige is redistributed in an iterative process whereby journals transfer their attained prestige to each other through the previously described connections. The process ends when the differences between journal prestige values in consecutive iterations do not surpass a pre-established threshold.

The SJR indicator is computed in two phases: the computation of the Prestige SJR (PSJR), a size-dependent measure that reflects the overall journal prestige; and the normalization of this measure to give a size-independent metric, the SJR indicator, which can be used to compare journals.

3.1. Phase 1

First, each journal is assigned the same initial prestige value $1/N$, where N is the number of journals in the database. Then the iterative procedure begins. Each iteration assigns new prestige values to each journal in accordance with three criteria: (1) a minimum prestige value from simply being included in the database; (2) a publication prestige given by the number of papers included in the database; and (3) a citation prestige given by the number and "importance" of the citations received from other journals. The formula used for this calculation is the following:

$$\mathrm{PSJR}_i = \overbrace{\frac{(1-d-e)}{N}}^{1} + \overbrace{e \cdot \frac{Art_i}{\sum_{j=1}^{N} Art_j}}^{2} + \overbrace{d \cdot \left[\sum_{j=1}^{N} C_{ji} \cdot \frac{\mathrm{PSJR}_j}{C_j} \cdot CF + \frac{Art_i}{\sum_{j=1}^{N} Art_j} \cdot \sum_{k \in DN} \mathrm{PSJR}_k \right]}^{3}$$

PSJR_i: Scimago Journal Rank of the Journal i. C_{ji}: references from journal j to journal i. C_j: number of references of journal j. d: constant: 0.9. e: constant: 0.0999. N: number of journals in the database. Art_j: number of primary items (articles, reviews, and conference papers) of journal j.

In the above formula, e and d are constants set to weight the amount of prestige that is achieved by means of publication and citation, respectively. Components 1 and 2, represented by the first two terms in the formula, are constant throughout the iteration, and together account for 10% of a journal's prestige value. Due to the complexity of Component 3, we will explain it in more detail.

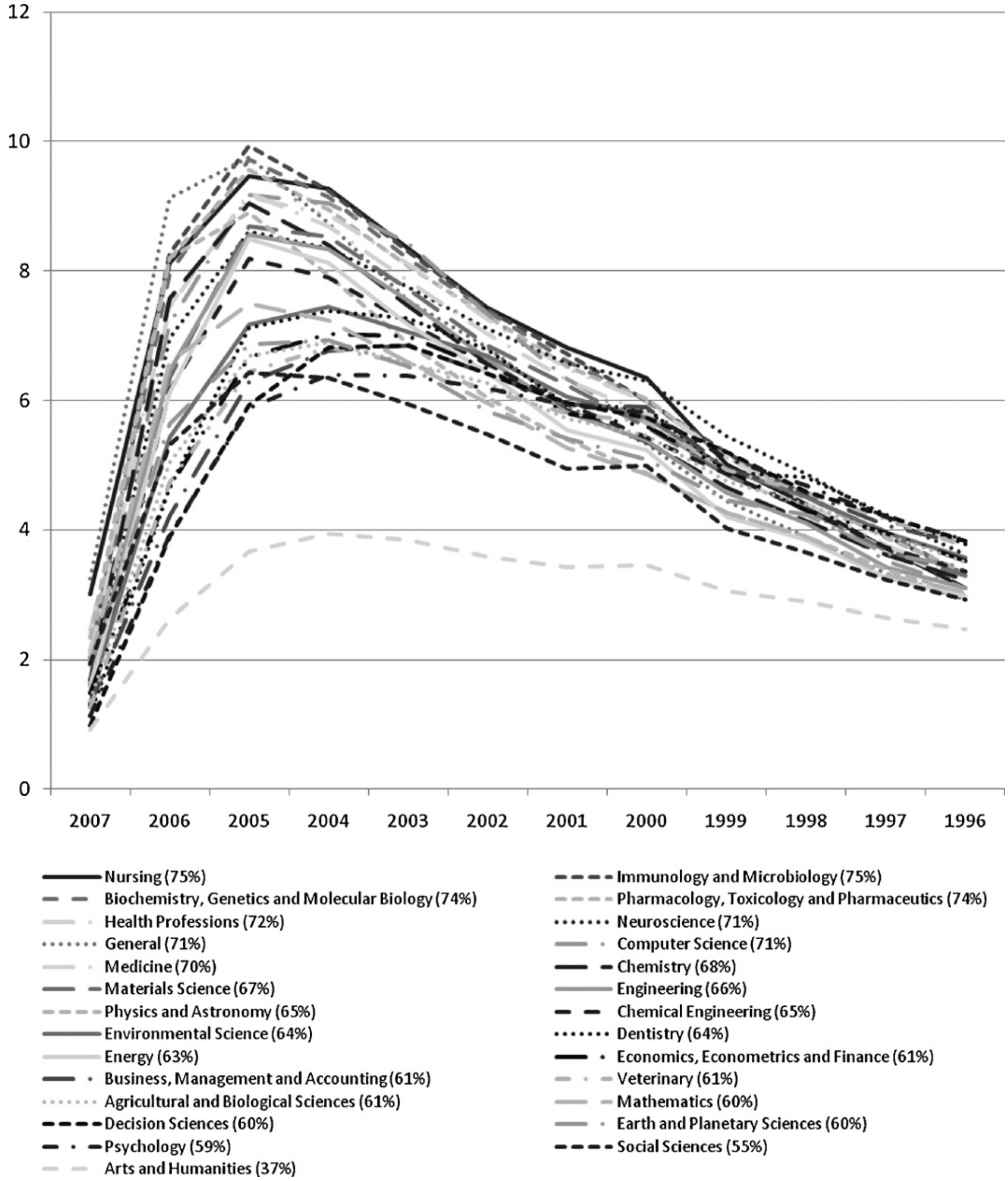

Fig. 1. Percentage for each of the last 12 years of the total references in articles published in 2007 and included in Scopus. In parentheses in the legend, the sum of these percentages.

The factor:

$$\sum_{j=1}^{N} C_{ji} \cdot \frac{\mathrm{PSJR}_j}{C_j} \cdot CF$$

represents the prestige transferred to journal *i* through the citations received from other journals. Each citation is weighted by the prestige achieved by the citing journal in the previous iteration divided by the total number of references found in that journal in the year being analyzed. Because only citations falling into the three-year window are used to distribute journal prestige, a procedure has to be defined to avoid losing the prestige value corresponding to the remaining citations in each iteration. To this end, a correction factor *CF* is introduced that spreads the undistributed prestige over all the journals proportionally to their accumulated prestige.

Table 1
Methodological differences between the SJR indicator, article influence, and impact factor.

	SJR indicator	Article influence	Impact factor
General differences			
Source database	Scopus	Web of science	Web of science
Citation time frame	3 years	5 years	2 years
Journal self-citation	Limited	Excluded	Included
Citation value	Weighted	Weighted	Unweighted
Specific differences			
Connections	Normalized by the total number of references in the citing journal	Normalized by the number of identified references in the citing journal	N.A.

The formula for *CF* is:

$$CF = \frac{1 - \left(\sum_{k \in DN} \mathrm{PSJR}_k\right)}{\sum_{h=1}^{N} \sum_{k=1}^{N} C_{kh} \cdot (\mathrm{PSJR}_k / C_k)}$$

The denominator corresponds to the amount of prestige distributed through the citations falling in the three-year window, and the numerator is the amount of prestige available to be distributed, i.e., unity minus the prestige accumulated by the "dangling nodes" which will be explained in the next paragraph.

Finally,

$$\frac{Art_i}{\sum_{j=1}^{N} Art_j} \cdot \sum_{k \in DN} \mathrm{PSJR}_k$$

distributes the prestige accumulated by the journals that do not cite other journals proportionally to the total number of primary items (articles, reviews, and conference papers) in the database. In the graph of the citation network, these journals are represented by nodes that have no outgoing connections, for which reason they are termed "dangling nodes".

The sum of the prestige values of all the journals in the database is normalized to unity in each iteration.

The iterative process terminates when the sum of the absolute values of all the changes in prestige does not surpass 0.001%.

3.2. Phase 2

The PSJR calculated in Phase 1 is a size-dependent metric that reflects the prestige of whole journals. It is not suitable for journal-to-journal comparisons since larger journals will tend to have greater prestige values. One needs to define a measure that is suitable for use in evaluation processes. To that end, the prestige gained by each journal, PSJR, is normalized by the

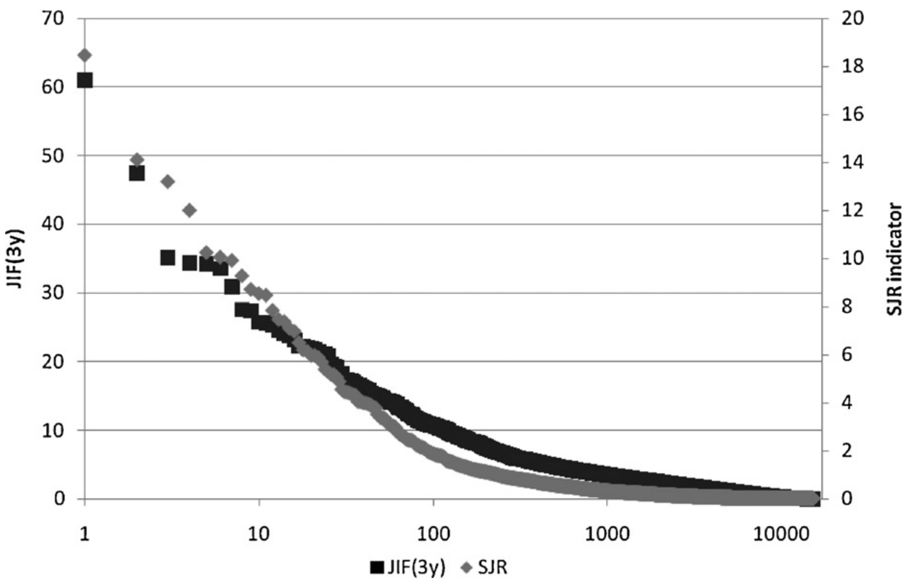

Fig. 2. Overlapping SJR indicator and JIF(3y) value *vs* rank distributions for the overall dataset.

number of primary items it has published (articles, reviews, and conference papers). Finally, these normalized PSJR values are increased proportionally to obtain an easy-to-use SJR indicator value. The procedure carried out in Phase 2 is given by the following formula:

$$\mathrm{SJR}_i = c \cdot \frac{\mathrm{PSJR}_i}{Art_i}$$

To put the methodological approach used to compute the SJR indicator in context, Table 1 presents a comparative synthesis of the principal differences between the SJR indicator, Eigenfactor.org's Article Influence, and Thomson Scientific's Impact Factor. We chose these two size-independent metrics for the comparison because of their extensive use as indicators in research evaluation.

4. Statistical characterization

We carried out a statistical characterization of the SJR indicator in order to contrast its capacity to depict what could be termed "average prestige per document" with the journals' citedness per document. In the following paragraphs, we shall present comparisons of the rank distributions and scatterplots of the SJR indicator and the Journal Impact Factor, both overall for the entire database, and for some of the "subject areas" and "specific subject areas" de Scopus. We constructed an *ad hoc* JIF(3y) with a three-year citation window so that any differences observed between the indicator values would be a consequence of the computation method and not of the time frame, citation window, etc. The study was performed for the year 2007 since its data can be considered stable. The data were downloaded from the SCImago Journal & Country Rank portal (http://www.scimagojr.com) on 20 December 2009. It needs to be noted that while, due to the periodic SJR updates which include retrospective data, the data of the present study may not coincide exactly with those given on the portal, they will be substantially the same.

Table 2
Average correlations of SJR indicator *vs* JIF(3y) by subject area and specific subject areas.

	Subject areas (27)	Specific subject areas (295)
Spearman	$\bar{x}=0.9338$ ||sd = 0.0409	$\bar{x}=0.9239$ ||sd = 0.0713
Pearson	$\bar{x}=0.8200$ ||sd = 0.1350	$\bar{x}=0.8582$ ||sd = 0.1242

Table 3
Statistical parameters of the SJR indicator and JIF(3y) distributions.

		Averages	Squared errors	Slope
Subject areas	SJR indicator	$\bar{x}=0.1364$ ||sd = 0.1338	$\bar{x}=1.5571$ ||sd = 2.0142	Sl = −1.2810
	JIF(3y)	$\bar{x}=1.2917$ ||sd = 0.6371	$\bar{x}=0.3276$ ||sd = 0.5683	Sl = −1.2881
Specific subject areas	SJR indicator	$\bar{x}=0.1333$ ||sd = 0.1554	$\bar{x}=0.4340$ ||sd = 1.1070	Sl = −0.9684
	JIF(3y)	$\bar{x}=1.3022$ ||sd = 0.7562	$\bar{x}=0.1496$ ||sd = 0.3224	Sl = −1.1875

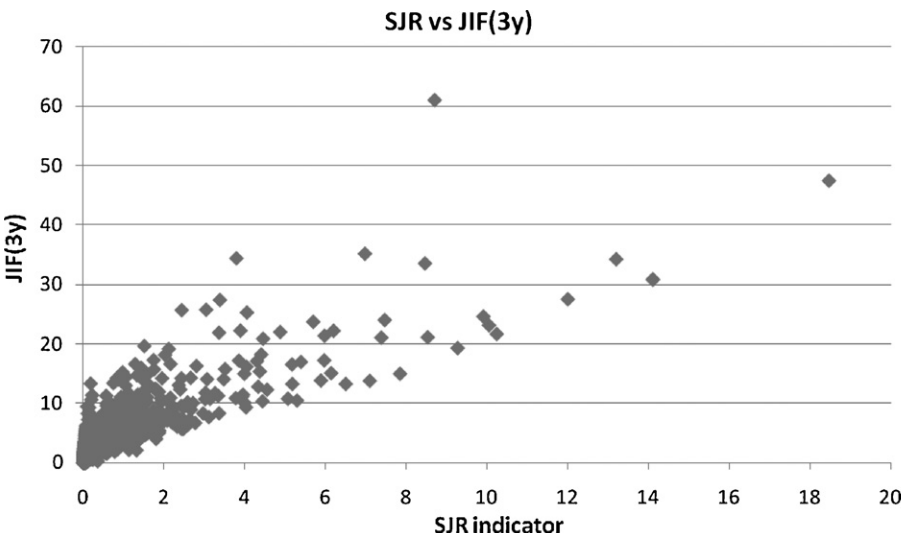

Fig. 3. Scatterplot of JIF(3y) *vs* the SJR indicator for the overall dataset.

Table 4
Top ten journals in the Scopus database, ranked by the SJR indicator and JIF(3y).

Title	SJR	Rank SJR	Rank JIF(3y)	JIF(3y)	Title	JIF(3y)	Rank JIF(3y)	Rank SJR	SJR
Annual Review of Immunology	18.477	**1**	2	47.393	*Ca-A Cancer Journal for Clinicians*	60.935	**1**	9	8.717
Cell	14.117	**2**	7	30.827	*Annual Review of Immunology*	47.393	**2**	1	18.477
Annual Review of Biochemistry	13.211	**3**	5	34.198	*Physiological Reviews*	35.120	**3**	16	6.991
Annual Review of Cell and Developmental Biology	12.013	**4**	8	27.558	*Reviews of Modern Physics*	34.351	**4**	46	3.810
Nature Immunology	10.253	**5**	21	21.715	*Annual Review of Biochemistry*	34.198	**5**	3	13.211
Nature Reviews. Molecular Cell Biology	10.061	**6**	16	23.175	*Annual Review of Neuroscience*	33.492	**6**	11	8.476
Nature Genetics	9.923	**7**	13	24.644	*Cell*	30.827	**7**	2	14.117
Immunity	9.284	**8**	27	19.341	*Annual Review of Cell and Developmental Biology*	27.558	**8**	4	12.013
Ca-A Cancer Journal for Clinicians	8.717	**9**	1	60.935	*New England Journal of Medicine*	27.434	**9**	50	3.400
Annual Review of Genetics	8.545	**10**	23	21.169	*Briefings in Bioinformatics*	25.784	**10**	58	3.059

Fig. 2 shows a superposition of the overall SJR indicator and JIF(3y) value *vs* rank distributions. They are both similar to a logarithmic law which would be represented in this semi-log plot by a descending, although steeper, straight line. The somewhat steeper fall-off of the SJR indicator distribution indicates that the prestige values are more concentrated, i.e., that there are fewer "prestigious" journals than highly cited ones. The two metrics are strongly correlated: their Spearman (rank) and Pearson correlation coefficients are 0.9331 and 0.8036, respectively. Generally, for the same journals, the SJR values are lower than the JIF(3y) values. Tables 2 and 3 give the statistical details of these statements.

Fig. 3 is a scatterplot of the same distributions as shown in Fig. 2. One observes that the SJR indicator tends to lower the JIF(3y) rank of some journals. Generally, this is the case with a journal that obtains many citations from relatively low importance journals, i.e., when the value of its centrality in the scientific discourse is lower than would be expected from its citedeness.

The results presented in Table 4 serve to confirm the strong correlation between the two metrics. It lists the top ten journals in each metric and their corresponding ranks. Five journals appear in both rankings, although their ranks differ.

In order to study the SJR indicator's behaviour in different scientific areas with distinct citation and publication patterns, we performed analyses involving several journal aggregations at the subject area and specific subject area levels. We shall describe three of these analyses corresponding to different Scopus categories.

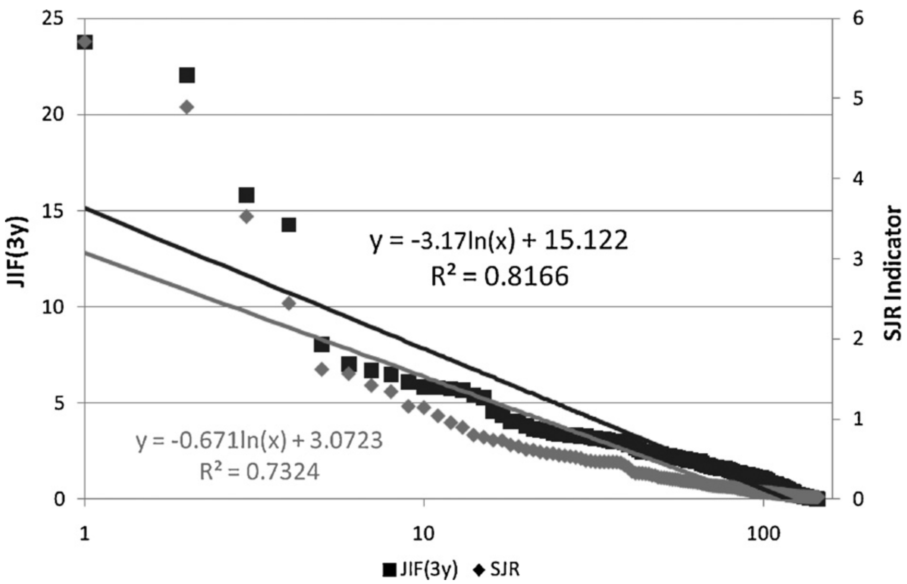

Fig. 4. Overlapping SJR indicator and JIF(3y) value *vs* rank distributions for the *Biochemistry, Genetics* & *Molecular Biology* (miscellaneous) specific subject area.

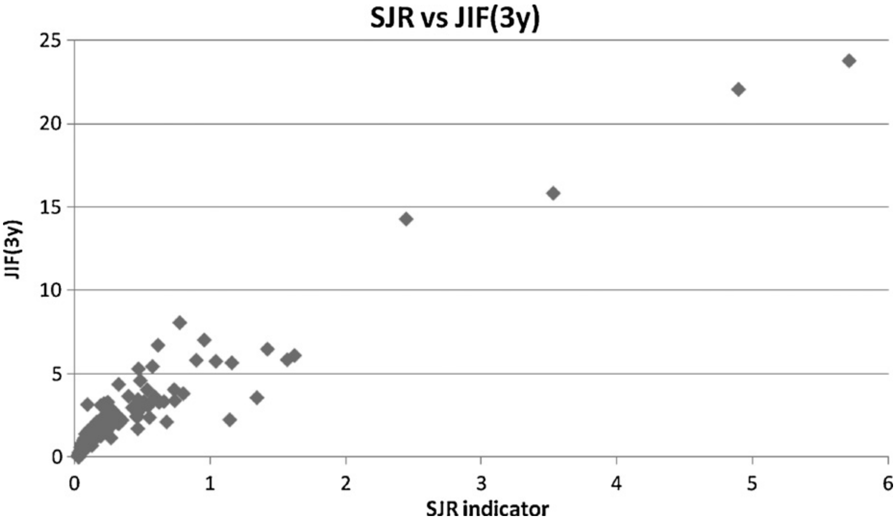

Fig. 5. Scatterplot of JIF(3y) *vs* the SJR indicator for the *Biochemistry, Genetics* & *Molecular Biology*(miscellaneous) specific subject area.

First, we shall consider the Life Sciences specific subject area of *Biochemistry*, *Genetics*, & *Molecular Biology* (miscellaneous), which consists of journals. Fig. 4 shows the SJR indicator and JIF(3y) distributions, including the best fit logarithmic regression straight lines, and Fig. 5 shows the corresponding scatterplot. The Life Sciences category is characterized by a general concurrence of journal prestige and citedness, as is reflected by the strong correlations between the values of the SJR indicator and JIF(3y): 0.9451 for the Spearman rank correlation coefficient and 0.9561 for the Pearson correlation coefficient, both well above the subject area means given in Table 2. In sum, one can say that, in this area, highly cited journals receive a high ratio of citations from journals which are in turn highly cited.

Table 5 shows five journals appearing in the top ten of both the SJR indicator and the JIF(3y) rankings. The differences between rankings were generally less than in the other comparative analyses of this study, except for the journal *Cold Spring Harbor Symposia on Quantitative Biology* which was ranked 10th by the SJR indicator but 53rd by JIF(3y), showing a clear example of a journal whose citation density is low in relative terms, but nevertheless manages to improve its position according to the SJR indicator since it receives citations from "more important" journals.

Table 5
Top ten journals in the Scopus specific subject area of Biochemistry, Genetics & Molecular Biology (miscellaneous), ranked by the SJR indicator and JIF(3y).

Title	SJR	Rank SJR	Rank JIF(3y)	JIF(3y)	Title	JIF(3y)	Rank JIF(3y)	Rank SJR	SJR
Nature Medicine	5.710	**1**	1	23.755	*Nature Medicine*	23.755	**1**	1	5.710
Annual Review of Plant Biology	4.894	**2**	2	22.039	*Annual Review of Plant Biology*	22.039	**2**	2	4.894
Cytokine & Growth Factor Reviews	3.529	**3**	3	15.811	*Cytokine & Growth Factor Reviews*	15.811	**3**	3	3.529
Progress in Lipid Research	2.445	**4**	4	14.268	*Progress in Lipid Research*	14.268	**4**	4	2.445
Molecular Systems Biology [electronic resource]	1.622	**5**	9	6.086	*Biological Reviews*	8.057	**5**	15	0.776
BioEssays: News and Reviews in Molecular, Cellular and Developmental Biology	1.568	**6**	10	5.832	*Journal of Cellular and Molecular Medicine*	7.014	**6**	12	0.957
Molecular Biology and Evolution	1.422	**7**	8	6.467	*Natural Product Reports*	6.699	**7**	21	0.615
Acta Crystallographica Section D: Biological Crystallography	1.345	**8**	23	3.555	*Molecular Biology and Evolution*	6.467	**8**	7	1.422
Cellular and Molecular Life Sciences	1.160	**9**	13	5.646	*Molecular Systems Biology* [electronic resource]	6.086	**9**	5	1.622
Cold Spring Harbor Symposia on Quantitative Biology	1.145	**10**	53	2.232	*BioEssays: News and Reviews in Molecular, Cellular and Developmental Biology*	5.832	**10**	6	1.568

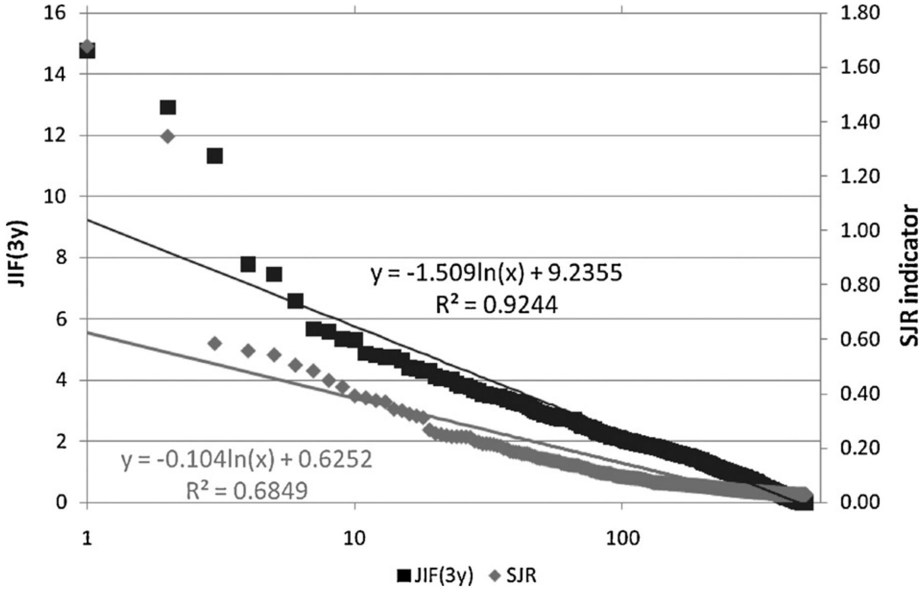

Fig. 6. Overlapping SJR indicator and JIF(3y) value *vs* rank distributions for the Psychology Subject Area.

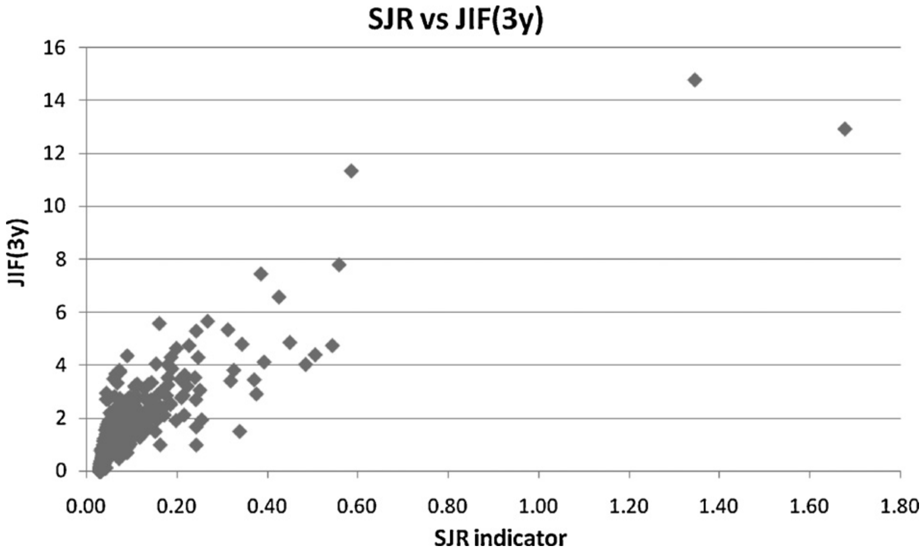

Fig. 7. Scatterplot of JIF(3y) *vs* the SJR indicator for the Psychology Subject Area.

Second, we shall consider a subject area in the Social Sciences category, in which it is known that the pattern of citation and publication is significantly different from that of the basic sciences (Nederhof, 2006). In particular, we analyzed the Psychology[1] subject area which comprises 484 journals. The results showed both indicators to closely follow a logarithmic law (Fig. 6), and to be strongly correlated with each other: Spearman rank correlation coefficient 0.9099, and Pearson correlation coefficient 0.8419, practically the same as the overall average values given in Table 2. In sum, one can say that there generally exists a strong correspondence between the notions of prestige and citedness in this subject area, although somewhat less so than in the previous specific subject area studied of *Biochemistry*, *Genetics*, & *Molecular Biology* (miscellaneous).

From the scatterplot in Fig. 7, one observes that there were no marked variations in the two sets of values.

In Table 6, one observes that five journals appeared in the top ten of both rankings, and that the first four positions are almost identical. There were no large rank changes except for the journal *Personality and Social Psychology Review*, which

[1] Psychology includes the Psychology (miscellaneous), Applied Psychology, Clinical Psychology, Developmental & Educational Psychology, Experimental & Cognitive Psychology, Neuropsychology & Physiological Psychology, and Social Psychology specific subject areas.

Table 6
Top ten journals in the Scopus Subject Area of Psychology, ranked by the SJR indicator and JIF(3y).

Title	SJR	Rank SJR	Rank JIF(3y)	JIF(3y)	Title	JIF(3y)	Rank JIF(3y)	Rank SJR	SJR
Trends in Cognitive Sciences	1.677	**1**	2	12.916	*Annual Review of Psychology*	14.767	**1**	2	1.345
Annual Review of Psychology	1.345	**2**	1	14.767	*Trends in Cognitive Sciences*	12.916	**2**	1	1.677
Psychological Bulletin	0.585	**3**	3	11.331	*Psychological Bulletin*	11.331	**3**	3	0.585
Psychological Review	0.558	**4**	4	7.789	*Psychological Review*	7.7891	**4**	4	0.558
American Journal of Medical Genetics–Seminars in Medical Genetics	0.543	**5**	14	4.755	*Bipolar Disorders, Supplement*	7.4444	**5**	11	0.385
American Journal of Medical Genetics–Neuropsychiatric Genetics	0.505	**6**	16	4.408	*Journal of Experimental Psychology: General*	6.5888	**6**	9	0.425
Neurobiology of Learning and Memory	0.484	**7**	22	4.043	*Journal of Abnormal Psychology*	5.6741	**7**	19	0.267
Psychological Science	0.449	**8**	11	4.872	*Personality and Social Psychology Review*	5.5909	**8**	51	0.16
Journal of Experimental Psychology: General	0.425	**9**	6	6.589	*Bipolar Disorders*	5.3527	**9**	18	0.312
Cognitive Psychology	0.392	**10**	20	4.133	*Psychotherapy and Psychosomatics*	5.3056	**10**	25	0.242

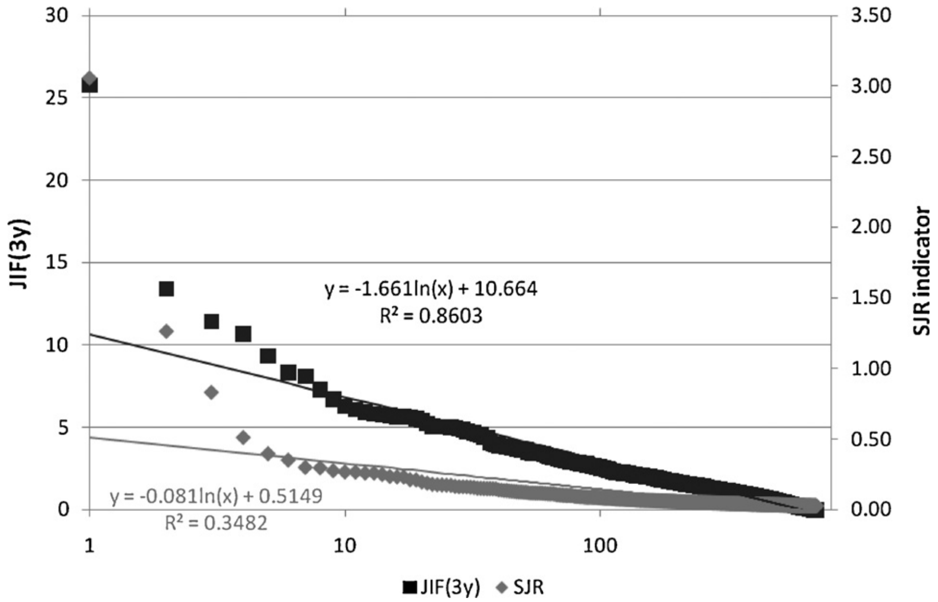

Fig. 8. Overlapping SJR indicator and JIF(3y) value *vs* rank distributions for the Computer Science Subject Area.

was ranked 8th by JIF(3y) but 51st by the SJR indicator. This is a journal that presents a clear ascent in the quantity and quality of citations received. Indeed, the value of its SJR indicator for 2008 was 0.342, placing it in 14th position in the SJR ranking.

Finally, we shall describe our analysis of the Computer Science Subject Area[2] in the Scopus Physical Sciences category, comprising 702 journals. Technical domains such as Computer Science are known to exhibit singular publication and citation patterns which differentiate them from other areas of science (Moed, 2005). One observes in Fig. 8 that here again both distributions closely followed a logarithmic law. The correlations between the values of the two metrics were, however, the lowest of those analyzed—0.9098 for the Spearman rank correlation coefficient and 0.6700 for the Pearson correlation coefficient. The scatterplot (Fig. 9) confirms this with the clearly large dispersion of the values, and one observes in Table 7 that there was only one journal in the top ten of both rankings. Two phenomena stand out. First, the top of the SJR ranking is overwhelmingly represented by multidisciplinary journals from the area of Life Sciences, in which citations are generally

[2] This includes the specific subject areas: Computer Science (miscellaneous); Artificial Intelligence; Computational Theory & Mathematics; Computer Graphics & Computer-Aided Design; Computer Networks & Communications; Computer Science Applications; Computer Vision & Pattern Recognition; Hardware & Architecture; Human-Computer Interaction; Information Systems; Signal Processing; and Software.

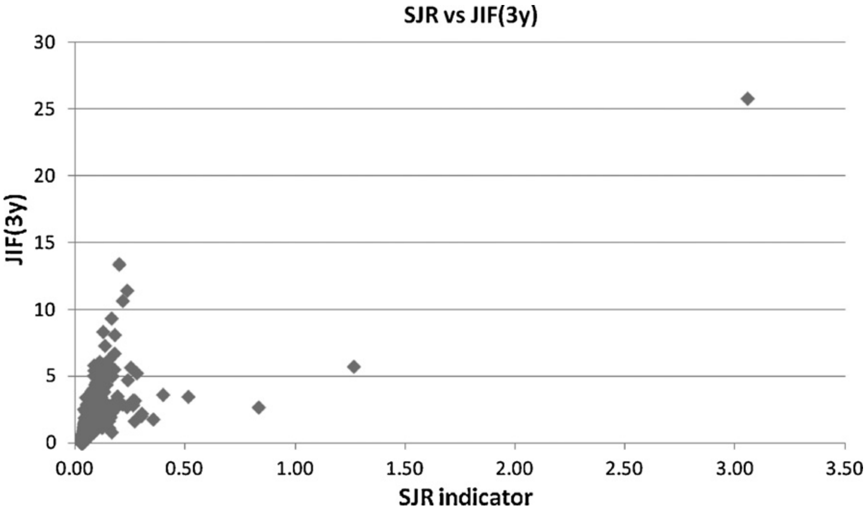

Fig. 9. Scatterplot of JIF(3y) *vs* the SJR indicator for the Computer Science Subject Area.

Table 7
Top ten journals in the Scopus Subject Area of Computer Science, ranked by the SJR indicator and JIF(3y).

Title	SJR	Rank SJR	Rank JIF(3y)	JIF(3y)	Title	JIF(3y)	Rank JIF(3y)	Rank SJR	SJR
Briefings in Bioinformatics	3.059	**1**	1	25.784	*Briefings in Bioinformatics*	25.784	**1**	1	3.059
Bioinformatics	1.267	**2**	15	5.743	*ACM Computing Surveys*	13.389	**2**	20	0.199
PLoS Computational Biology	0.834	**3**	92	2.686	*International Journal of Computer Vision*	11.432	**3**	16	0.235
Journal of Molecular Recognition	0.514	**4**	53	3.483	*Foundations and Trends in Communications and Information Theory*	10.667	**4**	18	0.215
Journal of Chemical Theory and Computation	0.399	**5**	50	3.629	*ACM Transactions on Information Systems*	9.353	**5**	30	0.164
Algorithms for Molecular Biology	0.354	**6**	180	1.792	*ACM Transactions on Graphics*	8.342	**6**	51	0.126
Quantum Information and Computation	0.302	**7**	123	2.213	*IEEE Transactions on Pattern Analysis and Machine Intelligence*	8.114	**7**	23	0.179
Computational Biology and Chemistry	0.299	**8**	150	2.028	*IEEE Transactions on Evolutionary Computation*	7.306	**8**	45	0.134
IEEE Transactions on Medical Imaging	0.279	**9**	21	5.249	*IEEE Signal Processing Magazine*	6.720	**9**	24	0.178
Journal of Chemical Information and Modeling	0.27	**10**	65	3.190	*IEEE Journal on Selected Areas in Communications*	6.267	**10**	36	0.152

more valuable. This explains why there appear journals in the top 10 with comparatively low citedeness. And second, the top of the JIF(3y) ranking is in turn overwhelmingly represented by IEEE and ACM journals which are characterized by their citation endogamy and their receiving many citations in relative terms from journals of little “importance”, e.g., from Lecture Notes in Computer Science whose citations are of low “value”.

5. Conclusions

This study has presented the development of the SJR indicator, a new metric of the scientific influence of scholarly journals aimed at use in conventional processes of research evaluation.

Since it is constructed on the Scopus database, we believe it will best reflect the citation relationships among scientific sources. However, at the same time, it will be necessary to adapt the PageRank method of computation to the particularly complex and heterogeneously structured characteristics of a citation network of this type.

Methodologically, the SRJ indicator establishes different values for citations according to the scientific influence of the journals that generate them. It uses a three-year citation window – long enough to cover the citation peak of a significant number of journals, and short enough to be able to reflect the dynamics of the scholarly communication process. It restricts a journal's self-citation to a maximum of 33% of its issued references so that excessive self-citation will not involve artificially inflating a journal's value, but without touching the normal process of self-citation.

Technically, the method proposes a solution to the known computational issues of PageRank-based methods with respect to the existence of journals which have no references to other journals in the database. For this purpose, the solution we use is to distribute these journals' accumulated prestige values among all the other journals in the database proportionally to their number of published papers. We also propose that the normalization of the connections between the journals is by means of the total number of references found in the citing journal instead of considering only those falling within the citation window. This obviates the issue of what to do with journals that transfer their accumulated prestige through so few references that they have little statistical significance.

The statistical characterization of the SJR indicator and its comparison with an *ad hoc* constructed method, JIF(3y), which was based on the unweighted counts of citations, provided quite conclusive results. While there existed a strong overall correlation between a journal's citedness and its scientific influence in terms of eigenvector centrality, there were also major changes in rank. Although both approximations closely follow a logarithmic law, scientific prestige is concentrated in fewer journals.

There was an observable general trend that the SJR indicator lowered the position of certain highly cited journals. Subsequent studies of this trend would help one to determine whether, as we intuit to be the case, this pattern is due to the SJR indicator reducing the rank of journals whose citedness is greater than would correspond to their scientific influence.

In sum, the SJR is a bibliometric indicator that measures the prestige or influence of a scientific journal, calculated with the bibliographic database that is the largest and most nearly complete for the period 2000–2009, and using a citation window of three years that is wide enough to include most of the citations, and dynamic enough to measure the evolution of scientific journals.

Finally, it is important to remember that today the constant growth in coverage of the two large citation databases (Scopus and WoS) makes it more necessary than ever to provide good journal metrics. The time has gone when all that mattered was whether or not the journal was indexed. Now that poorly cited journals are entering the indices, it is essential to have metrics that will allow one to distinguish with greater precision the level of prestige attained by each publication. A new generation of journal indicators needs to be made available to users for them to apply in the processes of evaluating and analyzing scientific production. Our hope is that, by drawing on some of the conceptual findings made in bibliometrics over the last few decades, the present proposal may play a relevant role in this context.

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