DOI: 10.1002/ejoc.200801243

Hirsch-Type Index Values for Organic Chemistry Journals: A Comparison of New Metrics with the Journal Impact Factor

Lutz Bornmann,*[a] Werner Marx,[b] and Hermann Schier[b]

Keywords: Journal Impact Factor / Hirsch-type indices / *h* index / *g* index / *h(2)* index / *a* index / *r* index

In August 2005, Jorge Hirsch introduced with the *h* index a new research performance indicator. His index is an original and simple new measure that incorporates both quantity and visibility of publications. Since 2005, a number of corrections and complementary indices to the *h* index as well as single-number alternatives have already been put forward. We examine in the present study the *h* index and the most important *h* index variants that have been proposed and discussed in the literature. The aim of the analysis is to determine empirically the extent to which the usage of the *h* index and its variants for measuring the performance of journals results in an incremental contribution against the Journal Impact Factor (JIF). JIF, *h* index, and different variants of the *h* index were calculated for 20 organic chemistry journals. As the findings reveal high intercorrelations, the different performance measures could be called redundant in empirical application.

1 Introduction

In August 2005, Jorge Hirsch – a physicist at the University of California, San Diego, USA – introduced a new research performance indicator. His index is an original and simple new measure incorporating both quantity and visibility of publications: "A scientist has index *h* if *h* of his or her N_p papers have at least *h* citations each and the other $(N_p - h)$ papers have $\leq h$ citations each."[1] All papers by a scientist that have at least *h* citations are called the "Hirsch core".[2] An *h* index of 20 means that a scientist has published 20 papers that each has at least 20 citations. Hirsch[1] originally suggested the *h* index for application at the micro level, that is, as a measure to quantify the scientific output of a *single* researcher. The *h* index was put forward as a better alternative to other citation-based metrics that could be used to measure research achievement (for example, total number of citations or citations per paper).[3,4]

The *h* index is seen to have the advantage that it gives a robust estimate of the broad impact of a scientist's cumulative research contributions.[1] This means that the *h* index is insensitive to a set of infrequently cited (or non-cited) papers or to one or several highly cited papers.[5] It combines number of publications and citation counts in a "balanced way":[6] It "represents an attempt to strike a balance between productivity and quality and to escape the tyranny of power law distributions which place strong weight on a relatively small number of highly cited papers".[7] The index favors "those authors who produce a series of influential papers rather than those authors who either produce many papers that are soon forgotten or produce a few that are uncharacteristically influential".[8] A study of Hirsch[9,10] found that the *h* index measures not only past productivity, but also predicts future productivity accurately.

Besides the advantages, a number of disadvantages of the *h* index have been named in recent months:[11,12] "One of these disadvantages is that it is insensible to high performances as it does not take the number of citations into account. Another disadvantage is that it never decreases even if a scientist has long stopped publishing."[13] Because of the disadvantages of the *h* index to quantify the scientific output of a scientist, a number of corrections and complementary indices to the *h* index as well as single-number alternatives have already been put forward.[4] The *a* index, for example, indicates the average number of citations of the publications in the Hirsch core. This index is meant to improve on the *h* index by giving more weight to highly cited papers than the *h* index does.

2 Hirsch-Type Indices for Journals

Hirsch[1] originally suggested the *h* index as a measure to quantify the scientific output of a *single* researcher. However, not only can the *h* index be used for the lifetime achievements of a single researcher but it can also be applied to any (more extensive) publication set.[14,15] Van Raan[16] calculates the *h* index for university research groups in chemistry and chemical engineering in the Netherlands. Braun et al.[6,17–22] propose a Hirsch-type index for evaluating the scientific impact of journals. The journal *h* index can be calculated as follows: "Retrieving all source

[a] Professorship for Social Psychology and Research on Higher Education, ETH Zurich,
Zähringerstr. 24, 8092 Zurich, Switzerland
E-mail: bornmann@gess.ethz.ch
[b] Max Planck Institute for Solid State Research,
Stuttgart, Germany

items of a given journal from a given year and sorting them by the number of times cited, it is easy to find the highest rank number which is still lower than the corresponding times cited value. This is exactly the *h*-index of the journal for the given year."[6]

The *h* index for journals was introduced as "a robust alternative indicator advantageously supplementing journal impact factors".[21] Journal impact factors (JIFs) are calculated by the scientific division of Thomson Reuters (Philadelphia, PA, USA) and are published annually in the Journal Citation Reports (JCR). The JIF was developed in the 1960s by Eugene Garfield and Irving H. Sher, who were concerned that by simply counting the number of articles a journal published in any given year, the small but influential journals in their Science Citation Index would be missed.[23] The JIF is the average number of times papers from the journal published in the past two years (e.g. 2005 and 2006) have been cited in the JCR year (e.g. 2007).[24] However, owing to the availability and utility of the JIF, promotion committees, funding agencies, and scientists have taken to using it as a shorthand assessment of the quality of scientists or institutions rather than only journals. "It has become vital to get papers into high impact-factor journals; just one such paper can change the prospects of a postdoc from nonexistent to substantial."[25]

According to Seglen,[26] JIFs are not statistically representative of individual journal papers and correlate poorly with actual citations of individual papers. A few highly cited papers can have a very strong influence on the JIF.[27] A study of Oswald[28] of six economics journals shows "that the best article in an issue of a good to medium-quality journal routinely goes on to have much more citations impact than a 'poor' article published in an issue of a more prestigious journal". Furthermore, the JIF is affected by calculation errors/inconsistencies (particularly because in the numerator all citations to all types of publications are counted, and in the denominator only the number of the so-called 'citable' documents is considered).[29] Since JIFs are very problematic when used for evaluation purposes, in the generic statement on criteria and working methods of the United Kingdom's Research Assessment Exercise,[30] it is stated that "no panel will use journal impact factors as a proxy measure for assessing quality".

Against the background of the JIF disadvantages, the *h* index and its variants applied to journals could be interesting alternatives. We examine in the present study the *h* index and the most important *h* index variants that have been proposed and discussed in the literature: *g* index,[31] *h(2)* index,[32] *a* index,[33] and *r* index.[34] The aim of the analysis here is to determine empirically the extent to which the usage of the *h* index and its variants for measuring the performance of journals does in fact result in an incremental contribution against the JIF, as it was claimed, for example, by Chapron and Huste[19] for journals focusing on biology: "If journals were ranked according to their *h* index, the hierarchy would better reflect journal status". Although the different performances measures may be conceptualized differently, in their empirical application, they may be highly correlated with each other. If the present study were to reveal high intercorrelations, the indices could be called redundant in empirical application.[35]

According to Harzing and van der Wal,[36] "examples of the application of the *h*-index to journals are still scarce". Our search in literature databases revealed that only four empirical studies have been published up until now. In the present study, we investigate for the first time the question of an incremental contribution of the *h* index and its variants against the JIF for chemistry-related journals.

3 Methods

3.1 Journals Considered in the Present Study

In 1976, Garfield[37] introduced the Journal Citation Reports (JCR) as an instrument to evaluate the significance of scholarly journals. Today, the most important journals worldwide are listed in the JCR with a series of bibliometric data and indicators (e.g. total citations and JIF). Each journal is classified in the JCR by using 172 subject categories. For chemistry, the categories analytical, applied, inorganic/nuclear, medicinal, multidisciplinary, organic, and physical are used.[38] The EUR J ORG CHEM belongs to the category organic. In the present study, we calculated the JIF and different variants of the Hirsch-type indices for this and for a further 19 journals that are assigned by Thomson Reuters to the organic subject category (see Table 1). We did not consider all 56 journals that are classified by Thomson Reuters in the JCR as "Chemistry, Organic". To have a comparable set of journals for statistical analyses, journals that specialize in certain substance classes (e.g. HETEROCYCL COMMUN and POLYCYCL AROMAT COMP) as well as journals that publish only minireviews (e.g. ALDRICHIM ACTA) or serials (e.g. ADV PHYS ORG CHEM and ADV HETEROCYCL CHEM) were excluded.

3.2 Definitions of the *h* Index Variants

g index: By holding that "a measure which should indicate the overall quality of a scientist ... should deal with the performance of the top articles", Egghe[31] proposed the *g* index as a modification of the *h* index. For calculation of the *g* index, the same ranking of a publication set – papers in decreasing order of the number of citations received – as that for the *h* index is used.[34] Egghe[31] defines the *g* index "as the highest number *g* of papers that together received g^2 or more citations. From this definition it is already clear that $g \geq h$". In contrast to the *h* index, the *g* index gives more weight to highly cited papers. The aim is to avoid a disadvantage of the *h* index that "once a paper belongs to the top *h* papers, its subsequent citations no longer 'count'".[39]

h(2) index: Like the *g* index, calculation of the *h(2)* index also gives more weight to highly cited articles: "A scientist's *h(2)* index is defined as the highest natural number such that his *h(2)* most-cited papers received each at least $[h(2)]^2$ citations".[32] An *h(2)* index of 20, for example, means that there are at least 20 papers in a paper set, of which each has been cited at least 400 times. Obviously, for any paper set, the *h(2)* index is always lower than the *h* index.

a index: According to Burrell,[40] "the *h*-index seeks to identify the most productive core of an author's output in terms of most received citations". The *a* index includes in the calculation only papers that are in the Hirsch core; it is defined as the average number of citations of papers in the core. The proposal to use this average number of citations as a variant of the *h* index was made by Jin, the main editor of *Science Focus*;[33] Rousseau[14] referred to this index later as the *a* index.

r index: Jin et al.[34] observed critically that with the *a* index, "the better scientist is 'punished' for having a higher *h*-index, as the *A*-index involves a division by *h*". Therefore, instead of dividing by *h*, the authors suggest taking the square root of the sum of citations in the Hirsch core to calculate the index. Jin et al.[34] refer to this new index as the *r* index, as it is calculated using a square root. As the *r* index – similar to the *a* index – measures the citation intensity in the Hirsch core, the index can be very sensitive to just a very few papers receiving extremely high citation counts.

Some alternatives to the *h* index, which are not relevant for the data set examined in this study, were not considered: As all journals for which indices were calculated in the present study publish organic chemical research, i.e. the journals are categorized by Thomson Reuters in the subject category "Chemistry, Organic," there is no need to compare index values across scientific disciplines or chemical subfields. For this reason, we did not use the standardizations of the *h* index developed by Batista et al.,[41] Iglesias and Pecharroman,[42,43] Imperial and Rodríguez-Navarro,[44] Levitt and Thelwall,[45] and Radicchi et al.[46]

3.3 Statistical Analysis

The aim of the analysis here is to determine empirically the extent to which the usage of the *h* index and its variants does in fact result in an incremental contribution against the JIF. We used for the analysis the most recent JIFs of the organic chemistry journals from the 2007 JCR Science Edition. These JIFs were calculated by dividing the number of citations in the year 2007 by the total number of papers published in the years 2005 and 2006 (we included all document types in the calculations). To make the Hirsch-type indices comparable to the JIF_{2007}, we used exactly the same time windows to calculate the index values: the publications in the years 2005 and 2006 and the citations of these publications in the year 2007.[47] In other studies,[36] different publication and citation windows are considered for the calculation of the JIF and the Hirsch-type indices. However, if the statistical analyses in these studies point out differences between the indicators in measuring scientific performance, it is not clear whether these differences are the result of different mathematical index concepts or different time windows used for the calculation.

The citation searches in the Science Citation Index (SCI, provided by Thomson Reuters) for the determination of the *h* index and its variants were conducted in November 2008 through the online database service STN International (http://www.stn-international.de/) operated by FIZ Karlsruhe in Germany. According to the JIF formula (which counts the citations of all document types dividing by the number of citable items: only articles, communications, and reviews), we included all document types in the calculations of the citations. The counting of the publications is not relevant when establishing the *h* index and its variants by citation ranking because the non-citable items usually appear outside the Hirsch core.

The type and strength of the correlation between different performance measures (e.g. JIF and *h* index) were determined by using Spearman's rank-order correlation. As we were reluctant to make the assumption of bivariate normality, we used the Spearman's rank-order correlation instead of the Pearson's product-moment correlation.[48] The assumption of bivariate normality was tested with the skewness and kurtosis test as described by D'Agostino et al.[49] but with the adjustment made by Royston.[50] The strength of the relationships between the measures are interpreted by using the guidelines of Cohen[51] and Kraemer et al.[52]

4 Results

Table 1 shows the number of publications (N_p) in 2005/2006, proportion of reviews among the publications (P_r), JIF_{2007}, *h* index, *g* index, *h(2)* index, *a* index, and *r* index calculated for 20 organic chemistry journals. Besides indicator values, rank orders for different sortings of the journals are presented. As Table 1 reveals, there is a great difference between the journals with regard to the number of publications in 2005/2006 (*min* = 45 publications in CURR ORG SYNTH; *max* = 3997 publications in TETRAHEDRON LETT) and the proportion of reviews (*min* = 0% reviews in ORG LETT and SYNTHETIC COMMUN; *max* = 71.1% reviews in CURR ORG SYNTH). Since the *h* index cannot be larger than the number of papers it is based on, Braun et al.[6] recommend that journals publishing only a few highly cited papers should not be included in a ranking list that is based on the *h* index – this concerns mainly journals that predominantly publish reviews.[27] As the *h* index for the journals in Table 1 with a few papers in 2005/2006 (N_p) and/or a high proportion of reviews (P_r) among the papers is clearly smaller than N_p, it is not necessary to follow the recommendation of Braun et al.[6] to exclude certain journals from this study.

The results in Table 1 indicate that the JIF, *a* index, and *r* index are able to differentiate better between the journals than the *h* index, *g* index, and *h(2)* index. The reason is that the first group of performance measures are decimal numbers and the second group integers. The worst differen-

Table 1. Number of publications (N_p) in 2005/2006, proportion of reviews among the publications (P_r), JIF_{2007}, *h* index, *g* index, *h(2)* index, *a* index, and *r* index calculated for 20 journals of the subject category "Chemistry, Organic" (sorted by JIF_{2007}). Besides indicator values, rank orders for different sortings of the journals are presented.

Journal	N_p	P_r[a]	JIF_{2007}	Rank by JIF_{2007}	*h* index	Rank by *h* index	*g* index	Rank by *g* index	*h(2)* index	Rank by *h(2)* index	*a* index	Rank by *a* index	*r* index	Rank by *r* index
ORG LETT	3060	0.0	4.802	1	25	1	29	1	5	1	30.92	3	27.80	1
CURR ORG CHEM	229	57.6	3.961	2	13	8	16	8	4	6	17.62	8	15.13	8
J ORG CHEM	3127	3.7	3.959	3	21	2	25	4	5	1	26.76	5	23.71	4
ORG BIOMOL CHEM	1195	2.7	3.167	4	15	6	27	2	5	1	38.93	1	24.17	2
EUR J ORG CHEM	1152	7.5	2.914	5	17	4	23	5	5	1	27.12	4	21.47	5
TETRAHEDRON	2564	4.6	2.869	6	18	3	26	3	5	1	32.17	2	24.06	3
CURR ORG SYNTH	45	71.1	2.844	7	7	11	8	11	2	12	8.29	14	7.62	12
SYNLETT	1555	1.9	2.763	8	15	6	19	6	4	6	21.13	6	17.80	7
TETRAHEDRON LETT	3997	0.1	2.615	9	17	4	19	6	4	6	19.94	7	18.41	6
SYNTHESIS-STUTTGART	1147	4.0	2.257	10	13	8	15	9	4	6	16.85	9	14.80	9
MINI-REV ORG CHEM	48	33.3	2.000	11	5	13	8	11	3	10	10.40	10	7.21	13
ARKIVOC[b]	606	2.5	1.253	12	8	10	9	10	3	10	9.50	12	8.73	10
LETT ORG CHEM	379	0.5	0.981	13	5	13	8	11	2	12	9.80	11	7.00	14
SYNTHETIC COMMUN	870	0.0	0.977	14	7	11	8	11	2	12	9.00	13	7.94	11
MOLECULES	260	4.2	0.940	15	5	13	6	15	2	12	6.40	16	5.66	15
ORG PREP PROCED INT	93	16.1	0.857	16	4	18	5	17	2	12	5.75	18	4.80	19
CHINESE J ORG CHEM	593	2.7	0.766	17	5	13	6	15	2	12	6.40	16	5.66	15
J SYN ORG CHEM JPN	204	42.2	0.628	18	4	18	5	17	2	12	6.75	15	5.20	17
RUSS J ORG CHEM+	660	2.6	0.511	19	4	18	4	20	2	12	4.25	20	4.12	20
INDIAN J CHEM B	560	0.2	0.368	20	5	13	5	17	2	12	5.20	19	5.10	18

[a] It should be mentioned here that the publication category "review" refers to the document type "review" as used by Web of Science (Thomson Reuters) for classifying the entire scientific literature. The document types assigned by the journals for classifying their own publications, however, may differ more or less from the categorization introduced by the database producer. [b] ARKIVOC data were cleared from publications covered in SCI with ANON as author. These papers with anonymous authors are editorial contributions, which cannot be matched.

tiation between the journals is visible for the *h(2)* index. It assigns only four ranks to the 20 journals in Table 1. This finding might be in agreement with the statement by Jin et al.[34] that the *h(2)* index "is not sensitive enough" to measure appropriately research performance. However, the missing precision of integers is not seen by all bibliometricians as a disadvantage. For Vanclay,[53] for example, the *h* index avoids as an integer "the false impression of precision conveyed by the three decimal points in the ISI impact factor".

The findings in Table 1 show some differences in the rank order of the journals depending on the performance measure. These differences are greater for some journals than for others: CURR ORG CHEM, for example, is one of the best performers in view of the JIF_{2007} (rank 2); sorted by *h* index or *g* index this journal is only on rank 8. In contrast, small differences between the rank orders are visible for the EUR J ORG CHEM. For all but one performance measure is the rank 4 or 5; in view of the *h(2)* index, the rank of this journal is 1. By investigating the different rank orders of the journals in Table 1 by appearance alone, it is difficult to ascertain whether there is really an incremental contribution of the *h* index and its variants against the JIF_{2007}. This question can only be answered by calculating correlation coefficients for the relationship between the different performance measures.

In Table 2, Spearman rank-order correlation coefficients for the relationship between the *h* index, *g* index, *h(2)* index, *a* index, *r* index, and JIF_{2007} are presented. All correlation coefficients are statistically significant (that means, the coefficients are significantly different from zero) and lie in a range that can be called much larger than typical in the applied behavioral sciences ($r \geq 0.70$). Similar high correlations are reported in the few other studies that investigated the relationship between the *h* index, its variants, and/or the JIF for business-relevant journals,[54] ecological journals,[20] economics and business journals,[27,36] and forestry journals.[22] Studies that tested the relationship between the *h* index and its variants by using publication and citation data for single scientists also found high correlation coefficients.[32,34,35,55–57]

Table 2. Correlations between *h* index, *g* index, *h(2)* index, *a* index, *r* index, and JIF_{2007} calculated for 20 journals of the subject category "Chemistry, Organic" (Spearman rank-order correlation coefficients).

	h index	*g* index	*h(2)* index	*a* index	*r* index	JIF_{2007}
h index	1.0000					
g index	0.9572[a]	1.0000				
h(2) index	0.9016[a]	0.9340[a]	1.0000			
a index	0.8910[a]	0.9732[a]	0.9331[a]	1.0000		
r index	0.9639[a]	0.9943[a]	0.9243[a]	0.9639[a]	1.0000	
JIF_{2007}	0.8686[a]	0.9168[a]	0.8545[a]	0.8860[a]	0.9086[a]	1.0000

[a] $p < 0.05$. If a correlation coefficient is statistically significant, it is significantly different from zero.

5 Discussion

Although the use of different performance measures results in somewhat different rank orders of the journals, the high correlations between the measures found in this and other studies indicate that the development of the journal *h* index and its variants has resulted in hardly any empirical incremental contribution against each other and the JIF. Apparently, these findings indicate a redundancy among the various indicators to measure scientific performance in empirical application. The various indicators seem to measure similar aspects of scientific performance. The advantage of the *h* index against the JIF (and against most of the *h* index variants) is its manageability: it is very easy to determine when the citation counts for every single paper in a publication set are known.

Any bibliometric indicator to measure scientific performance should be carefully checked for its validity and its ability to correctly represent scientific quality. The Joint Committee on Quantitative Assessment of Research[58] regard the validity of the JIF and *h* index as neither well understood nor well studied. According to Harnad,[59] "the natural criterion against which to validate metrics is expert evaluation by peers". Up until now, only four studies[5,16,60,61] have examined the validity of the *h* index by testing the relationship between a scientist's *h* index value and peer assessments of his or her achievements. In the only study for journals, Vanclay[22] compared an expert ranking of 27 forestry journals with Hirsch-type indices. Although the results of these studies are positive, we still need further studies that use extensive data sets to examine the *h* index (and the other performance measures) for use in different fields of application. Future research on the *h* index should no longer be aimed at developing new variants, but should instead test the validity of the existing ones.

As a basic principle, it is always prudent to use several indicators to measure research performance.[16,62] The publication set of a scientist, journal, research group, or scientific facility should always be described by using a multitude of indicators, such as the number of publications with zero citations, the number of highly cited papers, and the number of papers for which the scientist is first author. As publication and citation conventions differ considerably across disciplines,[63] it is also important to use additional bibliometric indicators that measure the "relative, internationally field-normalized impact" of publications[64] – for instance, the indicators developed by the Centre for Science and Technology Studies (CWTS; Leiden, the Netherlands). For Glänzel,[15] "the *h*-index is a useful supplementary indicator, enrichment for the bibliometric toolset, but it is certainly not suited to substitute advanced indicators which have long ago become standard in bibliometric work".

[1] J. E. Hirsch, *Proceedings of the National Academy of Sciences of the United States America* **2005**, *102*, 16569.
[2] R. Rousseau, *Science Focus* **2006**, *1*, 23.
[3] P. Jacso, *Library Trends* **2008**, *56*, 784.
[4] R. Rousseau, in *Proceedings of WIS 2008*, Berlin. Fourth International Conference on Webometrics, Informetrics and Scientometrics & Ninth COLLNET Meeting (Ed.: H. K. F. Havemann), Humboldt Universität zu Berlin, Institute for Library and Information Science (IBI), Berlin, Germany, **2008**.
[5] L. Bornmann, G. Wallon, A. Ledin, *Research Evaluation* **2008**, *17*, 149.
[6] T. Braun, W. Glänzel, A. Schubert, *The Scientist* **2005**, *19*, 8.
[7] S. Lehmann, A. Jackson, B. Lautrup, *Scientometrics* **2008**, *76*, 369.
[8] C. D. Kelly, M. D. Jennions, *Trends in Ecology & Evolution* **2006**, *21*, 167.
[9] J. E. Hirsch, *Proceedings of the National Academy of Sciences of the United States of America* **2007**, *104*, 19193.
[10] P. Ball, *Nature* **2007**, *448*, 737.
[11] L. Bornmann, H.-D. Daniel, *Journal of the American Society for Information Science and Technology* **2007**, *58*, 1381.
[12] L. Bornmann, H.-D. Daniel, *EMBO Reports* **2009**, *10*, 2.
[13] R. Rousseau, B. Jin, *Journal of the American Society for Information Science and Technology* **2008**, *59*, 2305.
[14] R. Rousseau, *Science Focus* **2006**, *1*, 23.
[15] W. Glänzel, *Science Focus* **2006**, *1*, 10.
[16] A. F. J. van Raan, *Scientometrics* **2006**, *67*, 491.
[17] A. Sidiropoulos, D. Katsaros, Y. Manolopoulos, *Scientometrics* **2007**, *72*, 253.
[18] T. Braun, W. Glänzel, A. Schubert, *Scientometrics* **2006**, *69*, 169.
[19] G. Chapron, A. Huste, *BioScience* **2006**, *56*, 558.
[20] J. D. Olden, *Ecoscience* **2007**, *14*, 370.
[21] A. Schubert, W. Glänzel, *Journal of Informetrics* **2007**, *1*, 179.
[22] J. K. Vanclay, *Journal of Informetrics* **2008**, *2*, 326.
[23] E. Garfield, *Journal of the American Medical Association* **2006**, 295, 90.
[24] W. Marx, *Angew. Chem. Int. Ed.* **2001**, *40*, 139.
[25] P. A. Lawrence, *Current Biology* **2007**, *17*, R583.
[26] P. O. Seglen, *British Medical Journal* **1997**, *314*, 498.
[27] A.-W. Harzing, R. van der Wal, *Journal of the American Society for Information Science and Technology* **2009**, *60*, 41.
[28] A. J. Oswald, *Economica* **2007**, *74*, 21.
[29] M. Rossner, H. van Epps, E. Hill, *Journal of Cell Biology* **2007**, *179*, 1091.
[30] Research Assessment Exercise, Research Assessment Excercise (RAE), Bristol, UK, **2006**.
[31] L. Egghe, *ISSI Newsletter* **2006**, *2*, 8.
[32] M. Kosmulski, *ISSI Newsletter* **2006**, *2*, 4.
[33] B. Jin, *Science Focus* **2006**, *1*, 8.
[34] B. Jin, L. Liang, R. Rousseau, L. Egghe, *Chinese Science Bulletin* **2007**, *52*, 855.
[35] L. Bornmann, R. Mutz, H.-D. Daniel, *Journal of the American Society for Information Science and Technology* **2008**, *59*, 830.
[36] A. W. Harzing, R. van der Wal, *Ethics in Science and Environmental Politics* **2008**, *8*, 61.
[37] E. Garfield, *Nature* **1976**, *264*, 609.
[38] L. Bornmann, L. Leydesdorff, W. Marx, *CHIMIA* **2007**, *61*, 104.
[39] A.-W. Harzing, *Reflections on the h-index*, retrieved from http://www.harzing.com/pop_hindex.htm on July 19, **2007**.
[40] Q. L. Burrell, *Journal of Informetrics* **2007**, *1*, 170.
[41] P. D. Batista, M. G. Campiteli, O. Kinouchi, *Scientometrics* **2006**, *68*, 179.
[42] J. E. Iglesias, C. Pecharromán, *Scientometrics* **2007**, *73*, 303.
[43] J. E. Iglesias, C. Pecharromán, in *Proceedings of the 11th Conference of the International Society for Scientometrics and Informetrics*, vol. 2 (Eds.: D. Torres-Salinas, H. F. Moed), Spanish Research Council (CSIC), Madrid, Spain, **2007**, pp. 862.
[44] J. Imperial, A. Rodríguez-Navarro, *Scientometrics* **2007**, *71*, 271.
[45] J. M. Levitt, M. Thelwall, in *Proceedings of the 11th Conference of the International Society for Scientometrics and Informetrics*, vol. 2 (Eds.: D. Torres-Salinas, H. F. Moed), Spanish Research Council (CSIC), Madrid, Spain, **2007**, pp. 876.
[46] F. Radicchi, S. Fortunato, C. Castellano, *Proceedings of the National Academy of Sciences of the United States of America* **2008**, *105*, 17268.
[47] D. F. Taber, *Science* **2005**, *309*, 2166.

[48] *StatXact: version 8* with *Cytel studio. Statistical software for exact nonparametric inference*, User manual volume 2, Cytel Software Corporation, Cambridge, MA, USA, **2007**.
[49] R. B. D'Agostino, A. Balanger, R. B. D'Agostino Jr, *The American Statistician* **1990**, *44*, 316.
[50] P. Royston, *Stata Technical Bulletin Reprints* **1991**, *1*, 110.
[51] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed., Lawrence Erlbaum Associates Publishers, Hillsdale, NJ, USA, **1988**.
[52] H. C. Kraemer, G. A. Morgan, N. L. Leech, J. A. Gliner, J. J. Vaske, R. J. Harmon, *Journal of the American Academy of Child and Adolescent Psychiatry* **2003**, *42*, 1524.
[53] J. K. Vanclay, *Journal of the American Society for Information Science and Technology* **2007**, *58*, 1547.
[54] G. Saad, *Scientometrics* **2006**, *69*, 117.
[55] I. K. Ravichandra Rao, in *Proceedings of the 11th Conference of the International Society for Scientometrics and Informetrics*, vol. 2 (Eds.: D. Torres-Salinas, H. F. Moed), Spanish Research Council (CSIC), Madrid, Spain, **2007**, pp. 655.
[56] R. S. J. Tol, *Journal of Informetrics* **2008**, *2*, 149.
[57] M. Schreiber, *Journal of the American Society for Information Science and Technology* **2008**, *59*, 1513.
[58] Joint Committee on Quantitative Assessment of Research, International Mathematical Union (IMU), Berlin, Germany, **2008**.
[59] S. Harnad, *Ethics in Science and Environmental Politics* **2008**, *8*, 103.
[60] L. Bornmann, H.-D. Daniel, *Scientometrics* **2005**, *65*, 391.
[61] B. G. Lovegrove, S. D. Johnson, *Bioscience* **2008**, *58*, 160.
[62] W. Glänzel, *Scientometrics* **2006**, *67*, 315.
[63] L. Bornmann, H.-D. Daniel, *Journal of Documentation* **2008**, *64*, 45.
[64] A. F. J. van Raan, *Measurement* **2005**, *3*, 1.

Received: December 15, 2008
Published Online: February 27, 2009

