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Comparative rank assessment of journal articles

Péter Vinkler*

Research Centre for Natural Sciences, Hungarian Academy of Sciences, P.O. Box 17, H-1525 Budapest, Hungary

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ABSTRACT

To take into account the impact of the different bibliometric features of scientific fields and different size of both the publication set evaluated and the set used as reference standard, two new impact indicators are introduced. The Percentage Rank Position (*PRP*) indicator relates the ordinal rank position of the article assessed to the total number of papers in the publishing journal. The publications in the publishing journal are ranked by the decreasing citation frequency. The Relative Elite Rate (*RER*) indicator relates the number of citations obtained by the article assessed to the mean citation rate of the papers in the elite set of the publishing journal. The indices can be preferably calculated from the data of the publications in the elite set of journal papers of individuals, teams, institutes or countries. The number of papers in the elite set is calculated by the equation: $P(\pi_v) = (10 \log P) - 10$, where P is the total number of papers. The mean of the *PRP* and *RER* indicators of the journal papers assessed may be applied for comparing the eminence of publication sets across fields.

1. Introduction

The aim of this publication is to present a comparative assessment method for approximating the international impact of journal papers in different scientific fields. The science political goal of elaborating the method was to assess the eminence of publications of three research institutes of the Research Centre for Natural Sciences of the Hungarian Academy of Sciences. The institutes are active in different fields of science, as it may be concluded from their name: Institute of Materials and Environmental Chemistry (IMEC), Institute of Molecular Pharmacology (IMP) and Institute of Organic Chemistry (IOC).

The *first generation* of the evaluative indicators in scientometrics (Vinkler, 2010a) represents primarily gross and specific indices, e.g. total number of publications or citations, sum of the Garfield (impact) factor of the journals where the papers assessed were published divided by the number of the corresponding papers (Publication Strategy), citations per journal paper (citedness or citation rate), etc. Because of the different influence of the bibliometric factors (e.g. mean number of references, ageing rate of information, preferred publication channels) in different fields, the first generation indices referring to articles in different fields are not comparable with each other.

The *second generation* of the evaluative indicators may be represented by contribution and relative indices. Such indices are e.g. number of articles published by a country in a scientific field related to all articles worldwide, or the *BMV* indicators (Relative Citation Rate, *RCR*, Relative Subfield Citedness, *RW*, and CCP/JCS_m, and CCP/FCS_m, see Vinkler, 2012a). The main problem concerning the application of relative impact indicators is finding appropriate reference standards.

The *third generation* of the impact indicators is built on the characteristics of the distribution of citations among publications. Such indicators are e.g. *h*-index (Hirsch, 2005), *g*-index (Egghe, 2006), *A*-index and *AR*-index (Jin, 2006; Jin, Liang, Rousseau, & Egghe, 2007), *w*-index (Wohlin, 2009), π-index and π_v-index (Vinkler, 2009a, 2010b), *CDS*-index (Vinkler, 2011), *I*3-index (Wagner & Leydesdorff, 2012), etc.

* Tel.: +36 20 2126252.
E-mail address: pvinkler@chemres.hu

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Table 1
Percentage Rank Position (*PRP*) values of journal articles depending on the number of publications in the publishing journal.

Rank number of the article	Total number of publications in the publishing journal						
	100	300	500	1000	2000	3000	5000
1	100.00	100.00	100.00	100.00	100.00	100.00	100.00
10	91.00	97.00	98.20	99.10	99.55	99.70	99.82
50	51.00	83.67	90.20	95.10	97.55	98.37	99.02
100	1.00	67.00	80.20	90.10	95.05	96.70	98.02
300	–	0.33	40.20	70.10	85.05	90.03	94.02
500	–	–	0.20	50.10	75.05	83.37	90.02
1000	–	–	–	0.10	50.05	66.70	80.02
2000	–	–	–	–	0.05	33.37	60.02
3000	–	–	–	–	–	0.03	40.02
5000	–	–	–	–	–	–	0.02

The mentioned third generation impact indicators generally prefer highly cited publications. Nevertheless, the indicators differ from each other in the classification method for distributing the publications by citation frequency. The indices depend strongly on the bibliometric features of the corresponding scientific field. Therefore, it is highly relevant to introduce comparative impact indices which may be independent of the specificities of the field.

A simple way to compare the publication impact of teams working in different fields is ranking the publications of the corresponding teams in the fields separately, and comparing the rank numbers (Vinkler, 2010a, chap. 11). Viera and Gomes (2010) recommend the application of deciles of publications by citation rate. The impact of the publications in a corresponding decile is measured by the mean citedness. Colliander and Ahlgreen (2011) calculated item-oriented mean normalized citation rates for measuring the citation impact indices according to Lundberg (2007), and ranked the institutes studied by the relative number of their top 5% publications. The calculation of percentage values for assessment purposes has several advantages over the widely used mean impact indices (Bornmann & Mutz, 2011). Bornmann and Marx (2013) suggested the application of percentiles to ensure correct assessment and fair comparison of individual publications. They applied reversed percentage values for obtaining greater value for publications which received more citations and are ranked relatively higher.

Here I suggest introducing a relative measure for assessing both individual journal papers and sets of journal publications according to the Practical Rank Score index (Vinkler, 2010a, chap. 11). Noting, Pudovkin and Garfield (2012) suggested introducing the rank normalized impact factors which are calculated by a similar formula as the Practical Rank Score index.

It is obvious that not only the bibliometric features of the field but also the size of the corresponding set is relevant in judging rank positions. The same position in a set consisting of a great number of items may be considered as more valuable than in a relatively smaller set (Tague, 1990). Here the Practical Rank Score index has been applied and expressed as the percentage of the total. Accordingly, the Percentage Rank Position (*PRP*) index can be calculated by Eq. (1).

$$PRP = 100\left[1 - \frac{r(a) - 1}{P}\right] \quad (1)$$

where $r(a)$ is the ordinal rank number of the article to be assessed and P is the total number of articles in the corresponding set.

The highest value of the *PRP*-index is 100% for the item ranked as 1st independent of the number of items in the set. The lowest value depends on the number of items in the set analyzed. The *PRP*-index of the item ranked last in a set consisting of 1000 items e.g. is 0.10%, see Table 1. It seems to be reasonable to score even the last ranked paper because also this paper, eventually without any citations, may have some information value. Noting, the papers published in the last year of the period studied can gather citations only later. The articles studied here are ranked by the decreasing number of citations obtained.

The relationship between the rank numbers (r = 1, 10, 50, 2000, 3000, and 5000) and *PRP* values (100.00, 99.82, 99.02, 60.02, 40.02, and 0.02) for a set consisting of 5000 items can be given by a linear function:

$$PRP = 100.02 - 0.02r \quad (2)$$

It may be supposed that the ordinal rank number of publications by citation is characteristic of their relative impact within the publishing journal. Accordingly the relative rank position of two publications in different journals and fields seems to be comparable. The idea finds support by the results referred to below.

The mean Garfield (impact) factor (*GF*) was calculated for the total and top 1%, 10%, 20%, and 50% of journals in particular fields. It was found that the ratio of the *GF* values of the corresponding subsets, e.g. the ratio of the mean *GF* of journals belonging to the top 1% related to the mean *GF* of journals in the top 20% was similar in each field (Vinkler, 2009b, 2010a, pp. 170–174, chap. 11). Similar phenomenon was found earlier by Radicchi, Fortunato, and Castellano (2008) concerning the relation of the mean of citation frequency of journal papers in different clusters classified by the citation frequency.

Table 2
Scientometric indicators applied in the article.

Name	Acronym	Calculation method
Publishing journal (reference standard)		
Size of the elite set	$P(\pi_v)_s$	$P(\pi_v)_s = [10 \log P(s)] - 10$ $P(s)$: total number of articles in the publishing journal in the publication year
Elite citation rate	$ECR(s)$	Total number of citations received by the articles in the elite set divided by its size, $P(\pi_v)_s$
Article assessed		
Citation rate (citedness)	$c(a)$	Number of citations obtained by the paper assessed during the citation period, $(t_c)_a$
Article rank	$r(a)$	Rank of the article evaluated within the publishing journal in the corresponding time period. The articles are ranked by the decreasing number of citations
Relative impact indicators		
Relative Elite Rate	*RER*	$RER = c(a)/\mathrm{ECR}(s)$
Percentage Rank Position	*PRP*	$PRP = 100[1 - (r(a) - 1)/P(s))]$

2. Data and methods

2.1. Methods for selecting elite (significant or core) journal papers

The assessment method introduced here prefers the application of the *elite set* of publications within the set to be analyzed. It may be easily accepted that only information in the publications of high impact (i.e. highly cited papers) may bring about advance in science. This concept was founded by Price (1963), Cole and Cole (1973) and Garfield (1979).

Some methods for the selection of the elite set within the set of publications are given below.

- Lotka-method (see Vinkler, 2009a).
- Application of the Square root law (Price, 1963).
- Calculating the Hirsch-index (Hirsch, 2005). (The share of documents in the *h*-core may be assumed as the elite.)
- Percentage method (0.01%, 0.1%, 1%, 10%, 50%) of the articles ranked by the decreasing number of citations (Web of Knowledge, Thomson Reuters).
- Rescaled citation distribution ($c_f = c/c_m$, where c_m is the average citation rate (C/P) for the corresponding discipline, and c is the actual number of citations obtained by the document evaluated. The c_f index is taken as an unbiased index for citation performance across disciplines.) (Radicchi et al., 2008; Castellano & Radicchi, 2009).
- Citation curve method (lower limits of the citation classes: a, $2a$, $4a$, $8a$. . ., upper limits of the classes: $(2a - 1)$, $(4a - 1)$, $(8a - 1)$. . ., where $a = 5$) (Wohlin, 2009).
- π-Method ($P(\pi) = \sqrt{P}$, where P is the total number of articles) (Vinkler, 2009a).
- π_v-Method ($P(\pi_v) = (10 \log P) - 10$) (Vinkler, 2010b).
- Characteristic score and scale method (application of Waring distribution for obtaining poorly, fairly, remarkably and outstandingly cited papers) (Glänzel, 2011).
- Number of significant papers (i.e. papers with more citations obtained than references given) (Kosmulski, 2011).
- Core documents (i.e. documents which are strongly interlinked with a large number of other documents based on similarity measures derived from bibliographic coupling) (Glänzel & Thijs, 2011).

Here the π_v-method is applied because of its simplicity and comparability across smaller and larger fields. The indicators calculated are given in Table 2.

2.2. Steps of the assessment

(1) Selecting the publication sets to be assessed. The journal articles published in 2001–2011 by the authors in three research institutes of the Research Centre for Natural Sciences (IMEC, IMP, and IOC) and cited in 2001–2012 have been selected for the assessment process. Naturally, different publication and citation periods may be selected according to the purpose of the assessment,
(2) ranking the publications in the corresponding sets by the decreasing number of citations,
(3) calculating the size of the corresponding elite sets (i.e. number of publications in the elite set, $P(\pi_v)$ within the total set of the publications assessed),
(4) selecting the corresponding reference sets. A reference set consists here of the publications in the corresponding publishing journal which appeared in identical year as the publication assessed,

Table 3
Data and indicators of the articles of the Institute of Organic Chemistry and that of the publishing journals.

Journal	Year	P_s	$P(\pi_v)_s$	$mECR_s$	SD	$c(a)$	$r(a)$	RER	PRP
Org. Lett.	2005	1499	22	189.41	57.46	394	1	2.08	100.00
J. Mass Spectrom.	2004	167	12	92.75	57.87	145	2	1.56	99.40
J.Am. Chem. Soc.	2006	3310	25	416.36	183.61	135	201	0.32	93.96
Biopolym.	2005	718	19	49.89	26.30	114	1	2.29	100.00
Angew. Chem. Int. Ed.	2008	1885	23	455.09	259.27	104	127	0.23	93.32
J. Chem. Phys.	2002	2523	24	316.60	208.64	90	112.5	0.28	95.58
Anal. Chem.	2003	1033	20	401.60	296.52	73	168	0.18	83.83
Green Chem.	2008	200	13	121.38	66.86	68	14	0.56	93.50
J. Am. Chem. Soc.	2009	3389	25	228.24	61.50	67	254	0.29	92.53
Top Cat	2008	115	11	48.36	17.42	65	2	1.34	99.13
Chem. Phys. Lett.	2004	1655	22	198.91	200.46	64	77.5	0.32	95.38
J. Am. Chem. Soc.	2009	3389	25	228.24	61.50	59	330	0.26	90.29
Inorg. Chem.	2004	593	18	52.22	12.28	58	5	1.11	99.33
J. Polym. Sci. Pol. Phys.	2001	304	15	96.40	57.42	57	17.5	0.59	94.57
J. Am. Chem. Soc.	2005	3437	25	477.24	200.53	57	1190.5	0.12	65.39
J. Phys. Chem. A	2004	1497	22	190.90	131.35	49	125.5	0.26	91.68
Electrochim. Acta	2002	429	16	191.31	94.77	46	91.5	0.24	78.90
Phys. Chem. Chem. Phys.	2001	832	19	163.42	124.70	36	111	0.22	86.78
Phys. Rev. B	2002	5570	27	406.93	219.11	28	1407	0.07	74.76

Year, publishing year of the article assessed and the corresponding journal; P_s, total number of publications in the corresponding journal in the year of publication; $P(\pi_v)_s$, number of publications in the elite set of the corresponding journal; *mECR*(*s*), Mean Elite Citation Rate of the publications in the elite set of the publishing journal; SD, standard deviation; $c(a)$, number of citations obtained to the publication assessed; $r(a)$, rank of the publication assessed in the publishing journal; *RER*, Relative Elite Rate; *PRP*, Percentage Rank Position.

(5) determining the total number of papers, $P(s)$ and the number papers in the elite set of the journal used as the reference standard in the corresponding year,
(6) ranking the papers in the journal used as standard by the decreasing number of citations (this can be made in WoS automatically),
(7) determining the citation rank number (r_a) of each journal paper assessed in the respective publishing journal,
(8) calculating the Percentage Rank Position (*PRP*) index and Relative Elite Rate (*RER*) for the individual articles and for the whole set analyzed.

The indicators introduced in the paper may be applied for assessing publications of scientists, teams, universities, or countries. The *PRP*-index seems to be appropriate for evaluating also scientific journals. Accordingly, the individual publications in the journals devoted to a field may be collected and ranked according to the decreasing frequency of citations. The number of publications in the elite set of the total can be calculated by one of the methods given above. The *PRP*-index for each publication in the elite set will be calculated. The sum of the *PRP*-indices (aggregate *PRP*-index) of the articles in the same journal is calculated. The eminence of a particular journal may be regarded the higher the higher its aggregate *PRP*-index.

The calculation of the *PRP*-index according to Eq. (3) may be demonstrated by Eq. (4) for the articles shown in Table 3.

$$mPRP = \frac{1}{J}\sum_{j=1}^{j}\left[100\left(1-\frac{r(j)-1)}{P(j)}\right)\right] \tag{3}$$

where J is the number of the articles assessed, $r(j)$ is the rank number of j-th article in the publishing journal and $P(j)$ is the total number of articles in the publishing journal.

$$mPRP = \frac{1}{19}\left[100-\left(1-\frac{1-1}{1499}\right)+100\left(1-\frac{2-1}{167}\right)+100\left(1-\frac{201-1}{3310}\right)\cdots 100\left(1-\frac{1407-1}{5570}\right)\right] = 90.96 \tag{4}$$

Naturally, we may calculate the mean *PRP*-index both for the papers in the elite set and also for the whole set analyzed.

I have calculated the Relative Elite Rate (*RER*) index (Eq. (5)) for characterizing the eminence of the individual journal publications and the respective set of publications. The *RER*-index of a single publication relates the number of citations obtained by the paper to the mean citation rate (citedness) of the papers in the elite set of the publishing journal which is regarded as reference standard.

$$mRER = \frac{1}{J}\sum_{j=1}^{j}\left(\frac{c(a)}{ECS(s)}\right)_i \tag{5}$$

where J is the total number of journal articles (i.e. journals), $c(a)$ is the number of citations received by the j-th article, whereas $ECR(s)$ is the citation rate of the papers in the elite set of the j-th journal.

Table 4
Indicators of the journal papers of the institutes studied.

Institute	Total number of journal papers $(P)_a$	Total number of citations $(C)_a$	C_a/P_a	Publication Strategy	Number of papers in the elite set, $P(\pi_v)_a$	Mean of the publication year of $P(\pi_v)_a$ papers	Mean Elite Citation Rate of $P(\pi_v)_a$ papers
Materials and Environmental Chemistry	1306	10,622	8.13	2.28	21	2003.00 (2.10)	79.29 (36.66)
Molecular Pharmacology	968	11,059	11.42	2.44	21	2003.57 (1.83)	120.67 (35.79)
Organic Chemistry	722	7009	9.71	2.06	19	2004.74 (2.64)	89.95 (80.06)

Publication Strategy: mean Garfield impact factor of the journals publishing $(P)_a$ papers.
Publication time-period: 2001–2011.
Citation time-period: from the publication year of the paper up to 30.11.2012.
$P(\pi_v)_a = (10 \log (P)_a) - 10$.
The SD values are in parentheses.

Table 5
Indicators of the reference sets of articles (i.e. standard: publications in the publishing journals).

Field of the journals	Total set Number of the journals studied	Mean number of papers in the journals in y_p	Mean citation rate of the papers	Elite set Mean size of the elite set $P(\pi_v)_s$	Mean Elite Citation Rate, $mECR(s)$
Materials and Environmental Chemistry	18	706.00 (523.14)	25.98 (9.82)	17.10 (3.62)	171.09 (120.93)
Molecular Pharmacology	21	1779.57 (2167.81)	56.82 (53.04)	27.42 (7.10)	330.46 (237.55)
Organic Chemistry	16	1712.89 (1511.96)	28.96 (12.44)	28.89 (20.00)	227.64 (143.42)

y_p, publication year of the journal.
The SD values are in brackets.

Applying the data in Table 3 we obtain:

$$mRER = \frac{1}{19}\left[\frac{394}{189.41} + \frac{145}{92.75} + \frac{135}{416.36} + \cdots + \frac{28}{406.96}\right] = 0.65 \tag{6}$$

3. Results

Table 4 contains some data and indicators calculated for the whole set of journal papers of the research institutes studied. Although the scientists of the institutes are active in different fields, their Publication Strategy (2.28, 2.44, 2.06, respectively) differs only slightly (the differences are not significant at $p < 0.05$). The citation rate of the papers in the total set (C/P: 8.13, 11.42, 9.71, respectively) and in the elite set (Mean Elite Citation Rate: 79.29, 120.67, 89.95, respectively) shows relatively greater differences.

Table 5 summarizes the indicators representing the journals (reference standards) which published the elite papers of the institutes. The number of the papers refers to the year (y_p) when the corresponding paper of the institute appeared in the journal. Naturally, a citation period of the same length was applied for both the paper of the institute assessed and for the papers in the publishing journal. The mean citation rate of the papers in the total set of journals shows that life science (here: Molecular Pharmacology) journals are preferably cited, in general. The ratio between the citation rate value of the elite papers and papers in the whole set is: 6.59, 5.82, 7.87, respectively for the selected journals in the fields studied (Materials and Environmental Chemistry, Molecular Pharmacology, Organic Chemistry).

Table 6 shows the mean Relative Elite Rate (*mRER*) index and mean Percentage Rank Position (*mPRP*) index of the institutes calculated according to Eqs. (4) and (6). IOC shows the highest *mRER* value (0.65) followed by IMEC (0.61) and IMP (0.54). The differences of the means are however not significant at $p < 0.05$.

Table 6
Mean Relative Elite Rate (*mRER*) and mean Percentage Rank Position (*mPRP*) indicator of the publication sets of the research institutes studied.

Institute	*mRER*	Ratio	*mPRP*	Ratio
Materials and Environmental Chemistry	0.61 (0.33)	1.130	91.42 (10.51)	1.021
Molecular Pharmacology	0.54 (0.36)	1.000	89.55 (14.74)	1.000
Organic Chemistry	0.65 (0.68)	1.204	90.96 (9.37)	1.016

The SD values are in brackets.

According to the mean Percentage Rank Position (*mPRP*) the relative international standing of the institutes seems to be similar: 91.42%, 89.55%, and 90.96%, respectively. It should be mentioned that the mean of the actual rank numbers of the papers (i.e. not normalized according to the size of the journal by *PRP*, Eq. (1) was found for the institutes as follows: IMEC: 75.50 (SD: 168.93), IMP: 90.83 (SD: 147.28), and IOC: 223.05 (SD: 391.36). The difference between the corresponding data points to the importance of the normalization by the number of articles in the publishing journal (i.e. size of the reference standard).

4. Conclusion

The evaluative impact indicators (*PRP*, *RER*) introduced here may represent different aspects of the assessment of publications by relative impact. The *RER*-index relates the actual number of citations of the article studied to the mean citation rate of the elite articles in the corresponding journal, whereas the *PRP* indicator normalizes the actual citedness position of the article assessed to the size of the publishing journal.

The *PRP* and *RER* indicators enable us to assess publications across science fields relatively easily. The calculation process is easily understandable and acceptable for the researchers, teams or institutes evaluated.

According to the indices studied here the international impact of the journal publications of the institutes seems to be similar. However, it is the responsibility of the directors and team leaders in the respective institutes to draw the obvious science political consequences and to maintain preferably the research of authors of the publications which proved to be eminent according to the *PRP* and *RER* indicators. And, it would be advisable to investigate the reasons why the publications of some other teams do not figure on the list of the eminent papers.

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