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Short Communication

RELATIONS OF RELATIVE SCIENTOMETRIC IMPACT INDICATORS. THE RELATIVE PUBLICATION STRATEGY INDEX

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Relations of three relative scientometric indicators (Relative Citation Rate, RCR, Relative Subfield Citedness, R_W, and Relative Publication Strategy, RP_S) are studied. R_W can be calculated by the percentage share of citations divided by that of publications. The findings indicate that publishing in journals with relatively high impact factor is a necessary but not sufficient condition for attaining a high R_W index.

Publication is an essential part of scientific research. Papers in scientific periodicals represent the most important input and output information pools for researchers working in natural science fields.[1] The *information value* of the individual periodicals is well known for scientists from practice. From the aspects of Scientometrics the information value of journals can be approximated by their *international impact* which can be characterized by the mean citedness of papers in them. A comparative indicator for characterizing international impact of periodicals was first suggested by *Raisig*.[2] *Impact factors* introduced by *Garfield*[3] are widely used for the assessment of information production of research organizations (persons, teams, institutes, countries).[4,5]

The assumption behind the assessment methods based on impact factors is that *the scientific impact of the paper evaluated would be the same as that of a mean paper in the journal where the paper was published.* It seems to be, however, much more reasonable to introduce a different concept, namely that of *Relative Publication Strategy* (RP_S).[6,7] (The index: sum of impact factors of journals weighted by the number of papers evaluated and published in them, divided by the number of papers,

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can be termed as *Publication Strategy.*) The RP_S index may characterize the *selection* from the possible publication channels made by the authors. The index *relates the weighted mean of impact factors of periodicals which publish the papers of the author evaluated working on a special field to the same value referring to those authors worldwide who publish in a set of periodicals dedicated to the same special field* [Eq. (1)]. The latter mentioned set of journals (absolute standard) is generally greater than that containing the papers evaluated.[1] (RP_S can be assumed in much broader sense, of course, namely, not only impact but several *characteristics* of the respective publications can be compared):

$$RP_S = \frac{\left(\sum_{j=1}^{J} n_j h_j\right) / N}{h_s} \tag{1}$$

where J is the total number of the publishing journals used by the authors evaluated, n_j is the number of papers evaluated in the *j-th* journal and h_j is the impact factor of the *j-th* journal, N is the total number of papers evaluated and h_s is the mean impact factor of journals dedicated to the respective subfield. The h_s value can be obtained by summing up the impact factors (*preferably weighted with the number of papers*) of the journals dedicated to the special fields, e.g. that in *Science Citation Index Journal Citation Reports*, and dividing the resulting sums by the number of the journals (preferably by the number of papers). The journals dedicated to the respective fields can be selected by several methods.[8]

The Relative Publication Strategy (RP_S) indicator can be *equal to unity* for the authors who publish in journals of an international impact (in the meaning of "impact factor") *identical to the average* of the respective discipline, field or subfield.

In order to characterize *relative international impact* of scientific papers, two types of indicators applying *different standards* have been suggested. The *Relative Citation Rate* (RCR) indicator [Eq. (2)][9] relates the citedness of papers (citations per paper) investigated to that of the journals used (i.e. mean impact factor), whereas *Relative Subfield Citedness* (R_W) (where *W* refers to "world") *relates the number of citations obtained by the set of papers evaluated to the number of citations received by a same number of papers published in journals dedicated to the respective discipline, field or subfield* [Eq. (3)].[10] For calculating specific or relative indicators the ratio of sums (e.g. C/N) is preferred over the sum of ratios (e.g. Σ (c_i/n_i) where c_i is the number of citations obtained to the i-th paper (n_i).[10]

$$RCR = \frac{C/N}{\left(\sum_{j=1}^{J} n_j h_j\right)/N} \qquad (2)$$

where *C* is the total number of citations obtained by papers *N*.

$$R_W = \frac{C}{N \cdot h_s} \qquad (3)$$

The *absolute standard* ($N \cdot h_s$) can be calculated by multiplying the number of papers evaluated by the *mean citedness of papers* on the respective subfield. Mean citedness (h_s) can be calculated as mentioned before.

The *RCR* indicator relates the mean impact of the papers evaluated to a standard selected by the authors themselves consequently, publishing in journals of relatively low impact factor and obtaining appropriate number of citations gives a ratio equal to unity, which is similar to publishing in journals of high impact factor and receiving a respective number. R_W compares, however, the total number of citations obtained to a quantity, which is independent of the authors i.e. citations attained by researchers working on the same field worldwide.

It is easy to conclude that the two indicators mentioned above are related by the Relative Publication Strategy (P_S) index as follows:

$$RCR = \frac{1}{RP_S} R_W \qquad (4)$$

Substituting ($RP_S \cdot h_s$) from Eq.(1) to Eq.(2) we obtain:

$$RCR = \frac{C/N}{RP_S \cdot h_s} \qquad (5)$$

From Eqs(3) and (5) it follows that $R_W = RP_S \cdot RCR$, which corresponds to a simple linear function.

It is worth noting that indicator R_W can be calculated for a given organization *within a given system* (e.g. all papers of countries on a field) by Eq.(6).

$$R_W = \frac{C\%}{P\%} \qquad (6)$$

where *C%* is the percentage share of the organization in citations and *P%* is its share in publications.

Eq.(6) can be proved mathematically as follows.

$$C\% = \frac{100\ C_i}{C_T} \tag{7}$$

$$P\% = \frac{100\ N_i}{N_T} \tag{8}$$

where C_i and N_i are the number of citations and papers of the i-th country (or team or any organization), respectively, whereas C_T and N_T are those of the total (i.e. all citations and all papers of the field).

Dividing Eq.(7) by Eq.(8) we obtain:

$$\frac{100\ C_i \cdot N_T}{100\ N_i \cdot C_T} = \frac{C_i}{N_i \cdot h_s} = R_W \tag{9}$$

because C_T/N_T is equal to the mean impact factor (h_s) of papers in the journals dedicated to the respective field.

Braun and coworkers[5] published publication and citation data and indicators for countries (1989–1993) on different fields (all fields combined, Organic Chemistry, Applied Physics, Solid State Physics, Analytical Chemistry, Physical Chemistry, etc.). From the data R_W and RP_S indicators were calculated for 44 countries by Eqs (1) and (6) (Table 1) and the respective plots were made, of which Fig. 1 shows the RP_S–R_W plot for all fields combined. The number of countries with RP_S values greater than unity which are above or below the *RCR line* were changing by fields. Countries, however, with an RP_S value lower than unity were to be found below the RCR line, with only some exceptions. These findings would indicate that publishing with a Relative Publication Strategy (RP_S) better than the international average (RP_S>1) gives *possibilities* for obtaining citations exceeding the mean. However, this chance is not to be exploited for all papers. A Relative Publication Strategy (RP_S) inferior to the international average, however, will lead almost in all cases, to a lower number of citations.

Linear correlation coefficients and statistical data for R_W, RP_S and RCR are given in Table 2.

Table 1
Relative Citation Rate (RCR), Relative Subfield Citedness (R_W) and Relative Publication Strategy (RP_S) indicators for 44 countries for all science fields combined (1989–1993)

Country	Share in publications (%)	Share in citations (%)	RCR	R_W	RP_S
USA	33.78	49.87	1.06	1.48	1.39
UK	8.09	8.65	1.07	1.07	1.00
Japan	7.89	6.81	0.95	0.86	0.90
Germany	6.32	6.35	1.09	1.00	0.92
USSR	5.86	1.12	0.79	0.19	0.24
France	4.79	4.56	0.99	0.95	0.96
Canada	4.16	3.99	0.96	0.96	1.00
Italy	2.78	2.12	0.86	0.76	0.88
Australia	2.07	1.79	0.96	0.86	0.90
Netherlands	1.97	2.26	1.10	1.15	1.05
India	1.87	0.59	0.55	0.32	0.57
Spain	1.60	0.94	0.76	0.59	0.77
Sweden	1.57	1.77	1.11	1.13	1.01
Switzerland	1.19	1.71	1.15	1.44	1.25
PR China	1.04	0.29	0.54	0.28	0.52
Israel	0.94	0.77	0.79	0.82	1.03
Belgium	0.82	0.80	0.99	0.98	0.99
Poland	0.76	0.31	0.67	0.41	0.60
Denmark	0.74	0.75	1.12	1.01	0.91
Finland	0.62	0.56	1.06	0.90	0.85
Czechoslovakia	0.56	0.21	0.78	0.38	0.48
Austria	0.55	0.45	0.99	0.82	0.82
Taiwan	0.51	0.21	0.69	0.41	0.61
Brazil	0.49	0.19	0.58	0.39	0.67
South African R	0.49	0.23	0.77	0.47	0.62
Norway	0.45	0.37	0.98	0.82	0.83
New Zealand	0.42	0.30	1.00	0.71	0.71
Hungary	0.33	0.16	0.69	0.48	0.71
Greece	0.30	0.13	0.66	0.43	0.65
Argentina	0.30	0.13	0.54	0.43	0.78
South Korea	0.29	0.10	0.64	0.34	0.56
Yugoslavia	0.29	0.10	0.61	0.34	0.58
Egypt	0.24	0.05	0.54	0.21	0.39
Bulgaria	0.24	0.06	0.57	0.25	0.41
Mexico	0.22	0.10	0.61	0.45	0.74
Turkey	0.18	0.04	0.52	0.22	0.47
Ireland	0.18	0.14	0.98	0.78	0.82
Hong Kong	0.16	0.09	0.76	0.56	0.69
Chile	0.16	0.07	0.75	0.44	0.60
Saudi Arabia	0.13	0.04	0.61	0.31	0.49
Portugal	0.13	0.06	0.72	0.46	0.70
Nigeria	0.13	0.02	0.43	0.15	0.43
Singapore	0.12	0.06	0.80	0.50	0.59
Romania	0.09	0.02	0.59	0.22	0.45

Remarks:

Total number of publications including six more countries 2 601 794.

Total number of citations including six more countries: 9 028 888.

Mean impact factor (h_s): 3.47.

Percentage shares and RCR values and data mentioned above are taken from Ref. 5.

Table 2
Correlation coefficients and statistical data for R_W, RP_S and RCR indicators of 44 countries taking into account all science fields combined

	R_W	RCR	RP_S	Mean	SD	SEM	95% Confidence interval
R_W	1			0.63	0.34	0.05	0.53 to 0.73
RCR	0.92	1		0.80	0.21	0.03	0.74 to 0.87
RP_S	0.96	0.78	1	0.74	0.24	0.04	0.67 to 0.81

Legends:
R_W: Relative Subfield Citedness.
RCR: Relative Citation Rate.
RP_S: Relative Publication Strategy.

Although the RP_S–R_W relations can be approximated by a linear function (e.g. Fig. 1, R_W=1.37 RP_S – 0.39), they could be better described by logistic or special Bradford-type functions. The *logistic* function may be of $y = a \log x + b$ type where a and b are subfield dependent constants. The *Bradford-type* functions may show two or three characteristic regions.[11] In the first region R_W, as dependent variable, is increasing concavely whereas in the second region approximately linearly. In some cases, however, after a short linear period, R_W starts to increase convexly (third region). The RP_S–R_W functions could be approximated by a Bradford-type graph with parameters given by *Ye-Sho Chen* and coworkers,[12] namely R=20.000 and (α, γ)=(0.2, 0.7).

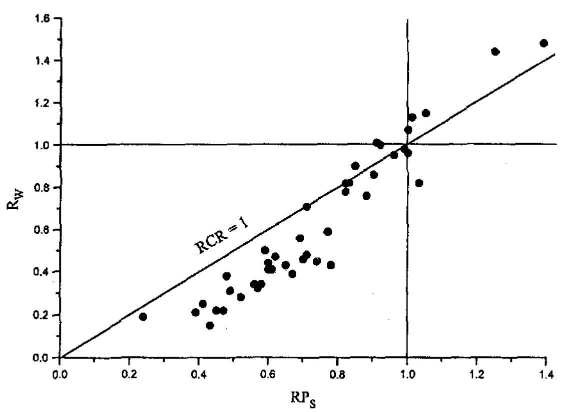

Fig. 1. Relationship between relative publication strategy (RP_S) and relative subfield citedness (R_W)

The findings indicate that publishing in journals with higher impact factor is a *necessary but not sufficient requirement* for attaining higher Relative Subfield Citedness (R_W) index. The phenomenon described can be coined as a "cumulative disadvantage" or "Second Type Matthew effect", namely "... *from him that hath not shall be taken away even that which he hath.*"

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