ORIGINAL PAPER

NEW METRICS FOR RESEARCH OUTPUTS FROM THE CHEMISTRY DEPARTMENT IN VALAHIA UNIVERSITY OF TARGOVISTE

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Abstract. *This article presents a further study related to the analysis of the scientific performance obtained by the Chemistry Department members from Valahia University using different scientometric indicators described in the scientific literature, including Hirsch index, selectivity and amplitude. The paper also contains the description of the method for calculating the Hirsch-index dependence on the Chemistry Department member's research age, determined from the publication of their first scientific paper. Some results concerning the h-index normalization by a factor that reflects the average number of co-authors are also included.*

Keywords: *research, Scientometrics, scientific productivity, Hirsch index.*

1. INTRODUCTION

In developed countries, basic and applied research is an important investment for long-term welfare. Scientometrics is one of the most important measures for the assessment of scientific outputs. The use of scientometric indicators in research evaluation emerged in the 1960's and 1970's, first in the United States of America and then, in different European countries. Those who contributed to the emergence of Scientometrics are Price de Solla (1963), Garfield (1955) and Narin (1976) in USA [1], Nalimov and Mulczenko (1969) in Russia [2] as well as Braun and Bujdoso (1975) in Hungary [3].

The Hirsch index [4] has been successfully used to evaluate researchers. This index is a measure of the number of papers published (productivity) as well as of how often they are cited (impact). Therefore [5]:

$$\text{Productivity} + \text{Impact} = \text{Influence} \quad (1)$$

The greatest advantage and most interesting property of this index is that it is easy to compute using on-line resources [6]. Considering these data, ISI classifies not only researchers but also universities, research institutes and even countries according to the number of published papers and, particularly, to the total number of citations for these papers [7]. Annual publications can thus be correlated with the number of citations that these publications have received.

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Review articles have a higher impact on the Hirsch index than original papers since they are generally cited more often [8]. The Hirsch index cannot be used to compare researchers from different fields [9]. Also, the Hirsch index does not account for the number of authors of a paper. At the same time, there is no difference of appreciation between the first, the last or the middle author [10].

The aim of this paper is to provide a quantitative characterization of the scientific activity of the Chemistry Department in Valahia University of Targoviste (UVT) using new scientometric indicators with interesting and unique attributes. The paper encompasses scientific documents of all types, such as articles, reviews, letters, conference papers etc, as collected by different databases (ISI Web of Science, Scopus or Google Scholar). Unfortunately, no database lists all the articles. For books, book chapters and most conference proceedings citations counts in databases are considered incomplete [5].

2. EXPERIMENTAL

The following forms of normalized Hirsch indices have been evaluated:

Parameter m, defined as [4]:

$$m = \frac{h}{y} \tag{2}$$

where h is the Hirsch index and y is the number of years passed since the first publication of the scientist.

Parameter h^n, defined as [11]:

$$h^n = \frac{h}{N_p} \tag{3}$$

where N_p is the total number of papers published by the scientist.

Also, the two new normalized indices that results from the Hirsch-type graphical representation will be evaluated, namely selectivity (S) and amplitude (A) [12] (Fig. 1).

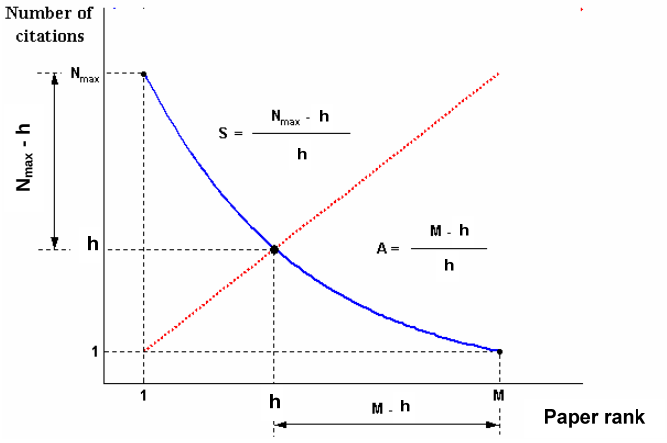

Fig. 1. Selectivity (S) and amplitude (A) in a Hirsch-type graphical representation [12].

Another index tested in this paper is the impact index (PI) for which the following calculation relations [13] have been proposed:

$$PI(\log) = \log(C^3 \cdot P) \quad (4)$$

$$PI(C) = 0.01(2C + P) \quad (5)$$

$$PI(2C) = 0.01(1.5C + P + 2C_{3P}) \quad (6)$$

$$PI(3C) = 0.01(1.3C + P + 3C_{3P}) \quad (7)$$

where C is the total number of citations and P is the number of papers and C_{3P} is the number of citations obtained by the three most cited papers.

3. RESULTS AND DISCUSSIONS

The h index is based on a list of papers ranked in descending order by the times cited. The value of h is equal to the paper rank (M) in the list that has N or more citations [4] (Fig. 1). Two parameters [12] can be defined: selectivity (S) and amplitude (or width) (A).

Structurally, one can have three kinds of the Hirsch-type curves as shown in figure 2 [12]. Curve (1) shows an equilibrated scientist, curve (2) is for a selective one while curve (3) determines a non-selective one.

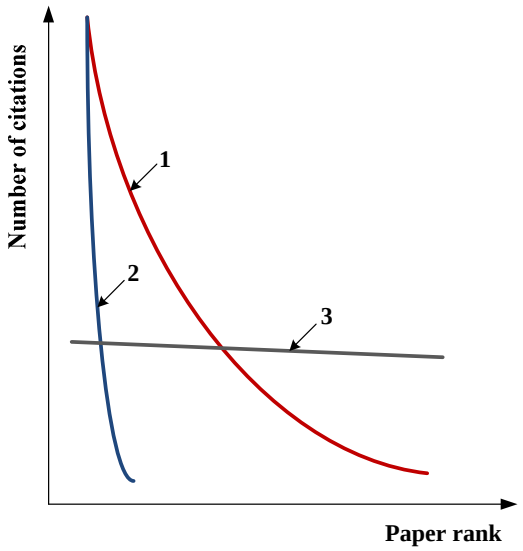

Fig. 2. Hirsch curves showing the equilibrated scientist (1), the selective scientist (2) and the non-selective scientist (3) [12].

Table 1 presents the S and A parameters for the Chemistry Department members in Valahia University of Targoviste, using Academic Google Scholar database. Databases have limitations and differences in their journal coverage [14].

Table 1. S and A parameters for the UVT Chemistry Department members using Academic Google Scholar database.

Code	Hirsch index (h)	Selectivity (S)	Amplitude (A)	S/A
P1	12.5	2.36	1.72	1.37
P2	12.0	2.50	1.83	1.36
P3	10.5	2.61	1.66	1.57
C1	7.0	1.28	2.28	0.56
C2	4.0	1.25	2.25	0.55
C3	3.2	1.18	1.50	0.78
L1	2.0	0.00	2.00	0.00
L2	2.0	0.50	2.50	0.20
A1	4.0	1.00	2.00	0.50
A2	4.0	1.25	3.50	0.35

Fig. 3 shows the linear dependence (correlation coefficient: 0.912) of the Hirsch index on the S/A ratio. The differences between the existing databases result in different values of the Hirsch indices as shown in table 2 and Fig. 4.

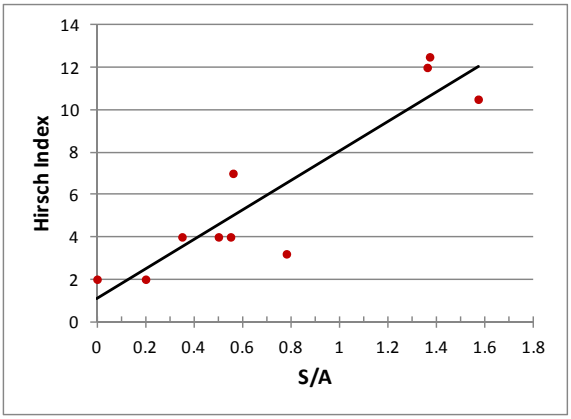

Fig. 3. Hirsch-index dependence on S/A ratio.

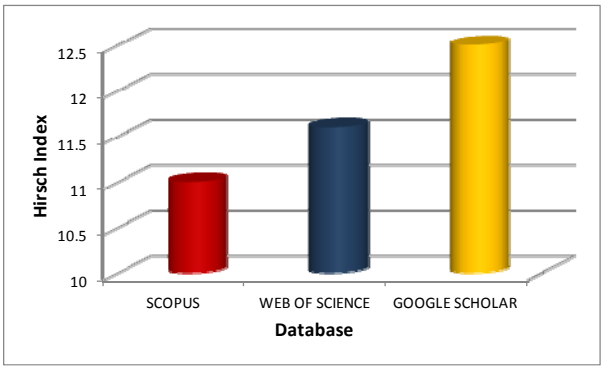

Fig. 4. Hirsch indices for P1 when using three different databases.

Table 2. Hirsch indices for P1 when using three different databases.

Database	Hirsch index (h)
SCOPUS	11.0
WEB OF SCIENCE	11.6
GOOGLE SCHOLAR	12.5

Taking into consideration that a researcher's h-index is approximately proportional to their career length [15], we have calculated the m-quotient by dividing the h-index by the number of years since the author's first paper.

The m-quotient is useful metrics to evaluate research outputs [16]. The m-quotient can be also used to discover talented young researchers [17]. According to Hirsch, a value of $m \approx 1$ characterizes a successful scientist, whereas an m value of approximately 2 and 3 represents of a remarkable and truly unique scientist, respectively. Anyway, the m-quotient appears to be the most accepted among academic and research establishments [18].

Kelly and Jennions [19] concluded that the Hirsch-index is dependent on the number of years spent in research by a teaching faculty member. Table 3, Fig. 5 and Fig. 6 present the attempt to correlate the Hirsch index with the number of years in research for the Chemistry

Department members. We have calculated in two ways, that is: since the publication date of the first paper and since the date of the first citation, respectively. Several papers have dealt with these issues [20 – 22].

To calculate the m parameter, we have adopted a number of calculation relationships such as the one shown bellow [24]:

$$m = -0.00567x + 0.00281z + 0.318 \quad (8)$$

where: x = years since first publication, z = number of publications and m = m-quotient.

Table 3. The Hirsch-index according to the UVT Chemistry Department members' research age, calculated in relation to the publication of the first paper and the first citation, respectively.

Code	Hirsch Index (Web of Science)	Scientific age*	First citation age**
P1	11	19	17
P2	11	19	17
P3	10	19	17
C1	7	16	9
C2	6	17	9
C3	6	15	8
L1	4	16	6
L2	3	14	6
A1	4	11	6
A2	3	14	9
A3	3	14	8

** We counted the scientific age as the year a researcher published their first paper. Within the legal framework in Romania this represents the length of service or seniority, according to which the first paper is considered the one published after the exam taken for the respective position;*

*** Cronin and Meho [23] suggest that the scientific age be counted beginning with the year in which a researcher received his/her first citation.*

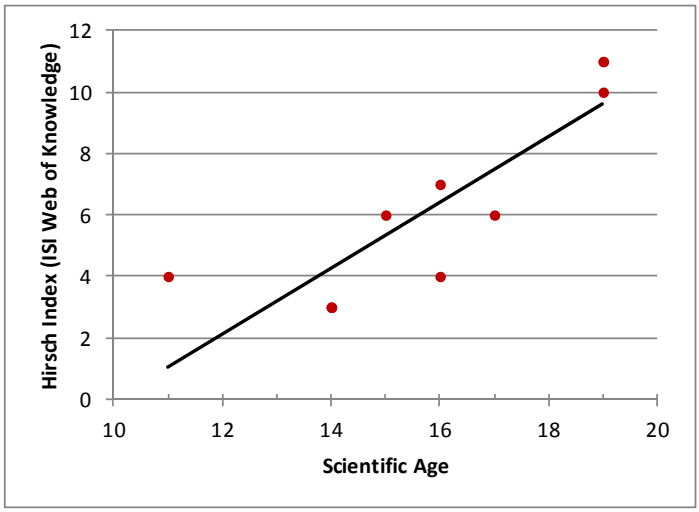

Fig. 5. Hirsch indices dependence on the Chemistry Department member's research age, calculated from the publication of their first scientific paper.

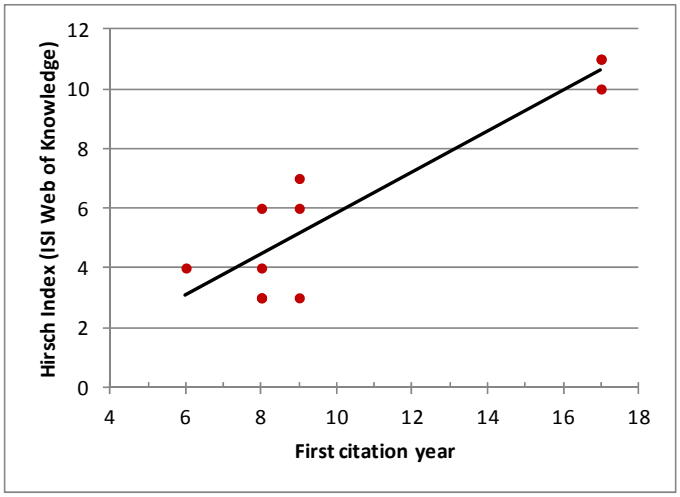

Fig. 6. Hirsch indices dependence on the Chemistry Department member's research age, calculated from the first citation.

The correlation of the research age with the number of years elapsed since the first scientific paper or the first citation, to present day, is not only a difficult problem but also an embarrassing one, since the publication of papers in foreign academic journals in those days needed the approval of the establishment's management. The same was valid for the presentation of a PhD thesis which required the approval by the local territorial sector of the communist party.

Table 4 presents the values of the m parameter calculated from dividing the Hirsch index by the age (number of years) considered as length of service and which includes exactly the time since the publication of the first paper.

Table 4. m-parameter values for the UVT Chemistry Department members.

Code	Hirsch index (h) (Web of Science)	m-quotient	m-quotient given by McCallum's relationship [24]
P1	11	0.57	0.65
P2	11	0.57	0.49
P3	10	0.52	0.36
C1	7	0.43	0.37
C2	6	0.35	0.34
C3	6	0.40	0.30
L1	4	0.25	0.27
L2	3	0.21	0.27
A1	4	0.36	0.29
A2	3	0.21	0.26
A3	3	0.21	0.28

A plot of the Hirsch-index versus the m-quotient is shown in figure 7, illustrating the close correlation between the two indices. The straight line obtained in this figure presents a good correlation coefficient (0.969). The dependence of the m size, which has been calculated using Mc Callum's relationship [24], on the Hirsch index results in a weak correlation coefficient (0.856).

It should be pointed out that no value of the m-parameter is super unitary or unitary so as to meet the requirements laid out by Hirsch [4]. The emergence of a change in the scientific research activity in Romania in 1989 accounts for the modification and/or renewal of thought in this field of activity.

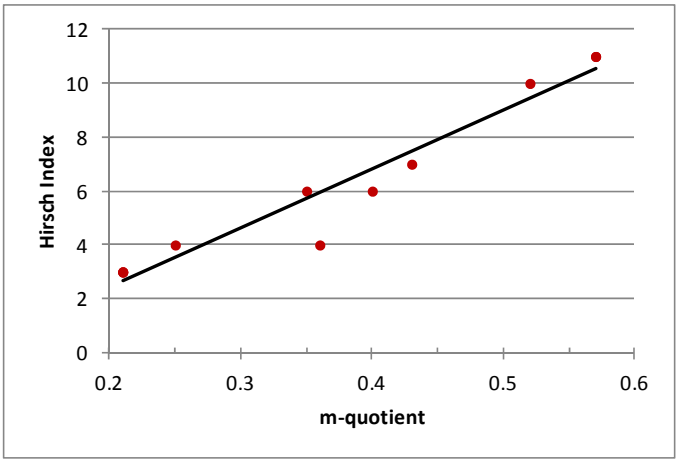

Fig. 7. m-parameter variation with Hirsch indices.

Table 5 shows the h^n index for the UVT Chemistry Department Members and figure 8 presents the Hirsch-index dependence on the h^n index.

A simple normalization is proposed sometimes to eliminate or reduce some disadvantages of the h-index (e.g. number of authors in the paper, self-citations etc.); thus, it allows comparing different researchers or domains more fairly. For instance, Hirsch [4] proposed to normalize the h-index by a factor that reflects the average number of co-authors [25].

Table 5. h^n indices for UVT Chemistry Department members.

Code	Hirsch index (h) (Web of Science)	Total number of papers (N_p)	$h^n = \frac{h}{N_p}$
P1	11	158	0.06
P2	11	101	0.10
P3	10	56	0.17
C1	7	56	0.12
C2	6	43	0.13
C3	6	27	0.22
L1	4	21	0.19
L2	3	14	0.21
A1	4	17	0.23
A2	3	17	0.17
A3	3	9	0.33

However, Figure 8 reveals the existence of a weak correlation between the two indices that have been analyzed (0.720). The analysis of the impact indices (PI) suggested by Vinkler [13] and their application to the UVT Chemistry Department members has led to the results presented in table 6 and figures 9 - 12. The analysis of these data shows that only linear dependence between the PI impact index and Hirsch index occurs in the case of the logarithmic relation (correlation coefficient 0.969). The other figures reveal an exponential dependence which becomes linear by logarithmic calculation. The correlation coefficients decrease in the order:

$$PI\ (3C) > PI\ (2C) > PI\ (C)$$

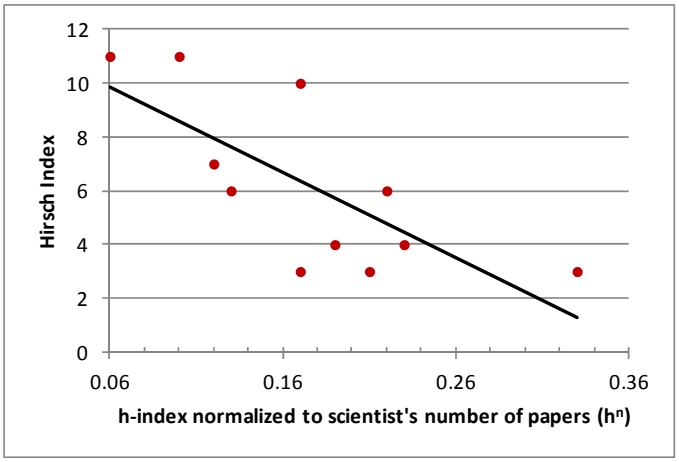

Fig. 8. h^n-index dependence on Hirsch index.

Table 6. Impact indices calculation for UVT Chemistry Department members.

Code	Total number of papers (N_p)	Total number of citations (C)	Number of citations from the 3 most cited papers (C_{3P})	PI(log)	PI(C)	PI(2C)	PI(3C)	Hirsch index (h) (Web of Science)
P1	158	665	111	10.7	14.90	13.80	13.60	11
P2	101	534	110	10.2	11.70	11.20	11.20	11
P3	56	337	101	9.3	7.30	7.60	7.90	10
C1	56	147	34	8.2	3.50	3.40	3.40	7
C2	43	91	29	7.5	2.20	2.30	2.40	6
C3	27	66	23	6.8	1.59	1.72	1.82	6
L1	21	30	18	5.8	0.81	1.02	1.14	4
L2	14	28	6	5.5	0.70	0.68	0.68	3
A1	17	34	19	5.8	0.85	1.06	1.18	4
A2	17	32	14	5.7	0.81	0.93	1.00	3
A3	9	27	21	5.2	0.63	0.91	1.07	3

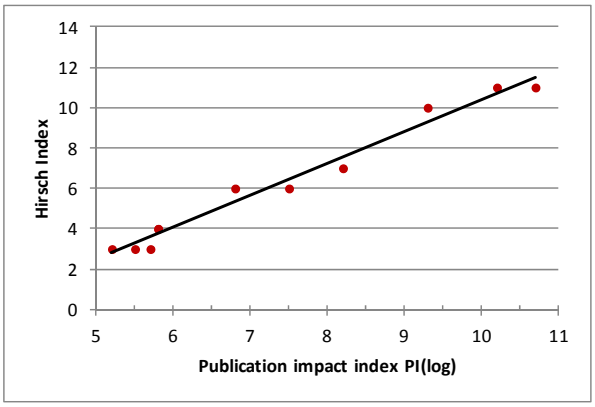

Fig. 9. PI(log) parameter variation with Hirsch index.

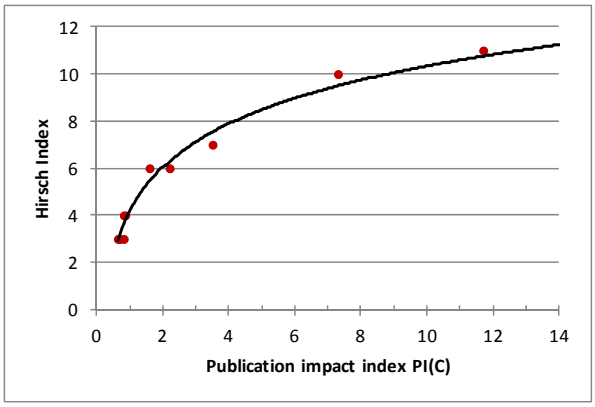

Fig. 10. PI(C) parameter variation with Hirsch index.

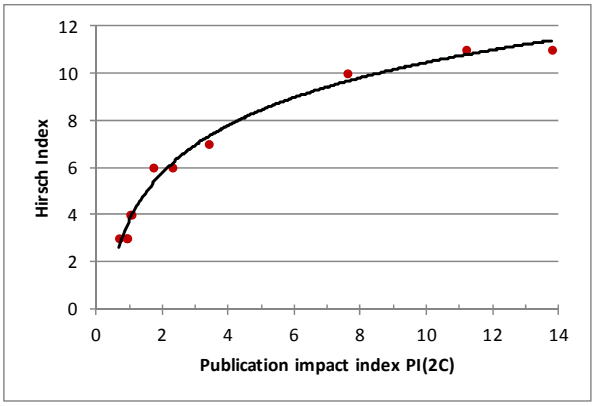

Fig. 11. PI(2C) parameter variation with Hirsch index.

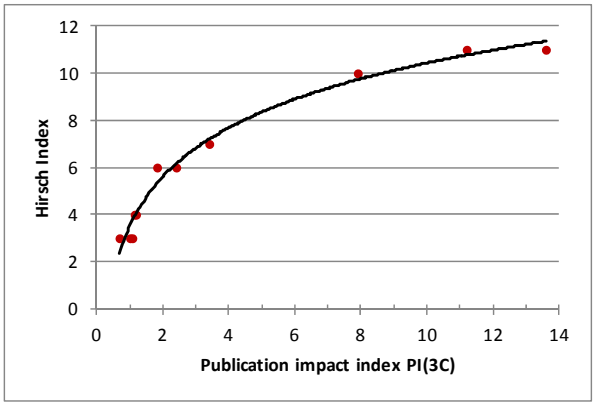

Fig. 12. PI(3C) parameter variation with Hirsch index.

These indices render a complex and gradual characterization of the impact of a researcher's papers. However, PI(3C) index provides the most complex characterization of scientific activity.

Table 7 shows Hirsch-index values for the UVT Chemistry Department members that have been obtained by different methods of calculation. A number of calculation relationships have been used as presented below [24]:

$$h = 0.133x + 0.0948z + 0.898 \quad (9)$$

$$h = 0.414x - 1.11 \quad (10)$$

$$h = 0.114z + 3.25 \quad (11)$$

where x is years since the first publication and z is the number of publications.

Also, we have used Nielson's relation [26]:

$$h = \frac{\sqrt{number\ of\ citations}}{2} \quad (12)$$

Budiman et al [29]:

$$h = 0.57\sqrt{number\ of\ citations} \quad (13)$$

and Csajbók et al [30], respectively:

$$h = c \cdot n^{1/3} \cdot \chi^{2/3} \quad (14)$$

where n = number of papers; χ = average citation rate; c = positive constant (c = 0.9 for journal analysis and C = 1 for rest of the cases).

Table 7. UVT Chemistry Department members' Hirsch index obtained by several methods.

Code	h (ISI Web of Science)	h Academic Google Scholar	h calculated by Nielson relation [26]	$\overline{h}$ calculated by the relation in the paper [24]	h calculated by the relation in the paper [29]	h calculated by the relation in the paper [30]
P1	11	12.5	12.9	15.5	14.7	14
P2	11	12	11.5	11.4	13.2	14.1
P3	10	10.5	9.2	8.4	10.5	12.6
C1	7	7	6.1	7.8	7.0	7.2
C2	6	4	4.8	7.1	5.4	5.0
C3	6	3.2	4.1	5.6	4.6	5.4
L1	4	2	2.7	5.4	3.1	3.5
L2	3	2	2.6	4.5	3.0	2.4
A1	4	4	2.9	4.2	3.3	4.2
A2	3	4	2.8	5.1	3.2	3.2
A3	3	-	2.6	4.2	3.0	4.3

The analysis of the data in table 7 clearly shows that the Hirsch-index values, which have been obtained by different methods, and relatively close. It is interesting to notice the chemists' world top in 2005. This includes the following personalities [27]: (1) George Whitesides, Harvard University (h = 135); (2) Elian James Corey, Harvard University (h = 132); (3) Martin Karplus, Harvard University (h = 129); (4) Alan Heeger, University of California, Santa Barbara (h = 114); Kurt Wüthrich, Swiss Federal Institute of Biology, Zurich (h = 113).

As for Romania, the Hirsch index has not exceeded two figures yet. The Hirsch-index has the advantage of allowing easy comparison between researchers of different ages in different fields [28].

Prominent researchers in medicine with a high h-index include Robert Gallo (h = 154) for HIV research and Bert Vogelstein (h = 151) for colon cancer research [28] a.s.o.

Most of our scientific papers were published in collaboration with two or more authors [31].

The idea of correcting the h-index for co-authors has been suggested by Hirsch himself [4], who proposed the normalization of the h-index by a factor that reflects the average number of co-authors. Similar ideas can be also found in Batista et al. [32], Campiteli et al. [33] and Wan et al. [34]. This index is marked h_I:

$$h_I = \frac{h}{\overline{T}} \tag{15}$$

but:

$$\overline{T} = \frac{T}{h} \tag{16}$$

and therefore:

$$h_I = \frac{h^2}{T} \tag{17}$$

where T is the total number of authors in "h-core". Table 8 presents the data obtained in the case of h_I index for the UVT Chemistry Department members.

Table 8. Correction index for co-authors (Academic Google Scholar)

Code	h	T	h_I	Code	h	T	h_I
P1	12	69	2.08	C1	7	45	1.08
P2	12	73	1.97	C2	6	27	1.33
P3	10	70	1.42	C3	6	35	1.02

The decrease of this correction index for the number of co-authors in relation to the Hirsch index is much higher in the case of our papers in comparison with other authors' papers [32, 35].

4. CONCLUSIONS

In this paper, we have tested new indices with interesting, unique attributes that complement the h-index. Basic properties as well as their relationship with Hirsch's h-index are also analyzed. The metrics has been applied to evaluate the research work of the Chemistry Department from Valahia University of Targoviste.

The ranking research groups by scientometric methods is a valuable tool for research evaluation that has been gaining popularity in today's scientific community.

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