*ORIGINAL PAPER*

# RESEARCH OUTPUT NEW EVALUATION OF CHEMISTRY GROUP IN VALAHIA UNIVERSITY WITH THE USE OF VARIOUS BIBLIOMETRIC INDICATORS

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***Abstract.*** *The current paper uses bibliometric data to investigate the research performance of the Chemistry Group from the Faculty of Sciences and Arts in Valahia University of Targoviste. The analyses are based on the Web of Science database. We present the research output such as the number of scientific papers and the citation impact as well as the Hirsch (h) and g indices. In addition, in this paper, we have applied new indices to characterize the scientific productivity of the researchers.*

***Keywords:*** *research, Scientometrics, bibliometric indicators, Hirsch index*

## 1. INTRODUCTION

Overall, scientific research represents one of the most important indices regarding a university's output and its quality standards.

Scientometrics can be defined as the measurement of scientific research. Modern scientometrics is mostly based on the work of Derek John de Solla Price and Eugene Garfield. Bibliometrics is a branch of scientometrics that focuses mainly on the study of scientific papers for statistical purposes. Bibliometric analysis can be used to identify new research areas to evaluate the research performance of individual scientists [1], research groups [2] and countries [3]. Bibliometric methods were also used as an evaluation tool of research performance of the fundamental disciplines, such as Mathematics, Physics and Chemistry.

The number of papers published within a period of time by a staff member or/and a department, faculty or university constitutes a bibliometric index as defined by Alan Pritchard in 1969 [4]. Performance indicators are based on the assumption that the quality of a researcher is given on only by the number of papers published but also by the frequency of citation in other papers. The Hirsch – index (*h*) combines these two above mentioned parameters [5].

This current paper continues a series of previous papers regarding the scientific output published by the Chemistry Department staff members [6-9] and is intended to bring an update of the scientometric indices that are characteristic to the department's group of researchers.

## 2. EXPERIMENTAL

The source for bibliometrics is always a database. In this study we have used Thomson Reuters' Web of Science (WoS) which covers almost 8000 current peer reviewed journals in different scientific fields. Although the WoS lists several types of documents, only

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original papers and review papers have been retained in our study. Thus, the following parameters were recorded: the number of papers (P), the total number of citations (C), the average citations on paper (C/P) and the h-index. In continuation of the presentation of the Hirsch index calculation begun in a previous paper [7], Table 1 shows the author who proposed these relations.

**Table 1 – New relations of h-index calculations existing in field literature.**

| Relation of h-index calculation | References | Relation of h-index calculation | References |
|---|---|---|---|
| $h = \sqrt{\frac{C}{\ln P}}$ | [10, 11] | $h = 0.57\sqrt{C}$ | [13, 14] |
| $h = 0.5\left(\sqrt{C} + 1\right)$ | [12] | $h = \frac{\sqrt{C}}{2}$ | [15-17] |

where $C$ is the total number of citations and $P$ represents the total number of papers.

Table 2 presents new parameters based on different types of means of the h and m indices proposed by Aliguliyev and Hasanova [18] that ensure a more balanced image of a researcher's scientific output.

**Table 2 – New scientometric parameters for the evaluation of the researcher's scientific output [18].**

| Parameter | Significance | Parameter | Significance |
|---|---|---|---|
| $R_{h,m} = \sqrt{\frac{h^2 + m^2}{2}}$ | Root mean square of h and m indices | $G_{h,m} = \sqrt{h \cdot m}$ | Geometric mean of h and m indices |
| $A_{h,m} = \frac{h + m}{2}$ | Arithmetic mean of h and m indices | $H_{h,m} = \frac{2h \cdot m}{h + m}$ | Harmonic mean of h and m indices |

where $h$ is the Hirsch index and $m$ is the median number of the citations received by the articles in the Hirsch core.

The $g$ index has also been determined using the method proposed by Egghe [19].

## 3. RESULTS AND DISCUSSIONS

The scientometric parameters that determine a researcher's scientific performance can be, for instance, the total number of published papers (P), the total number of citations (C) obtained by these papers, the number of citations per paper (C/P), the number of citations per year, the Hirsch index (h), the g index and so on. Table 3 presents the parameters for the Chemistry Department academics in the Faculty of Sciences and Arts of Valahia University Targoviste (UVT).

**Table 3 – Scientometric indicators that pertain to the scientific output of the UVT Chemistry Department academics (database: ISI Web of Knowledge).**

| CODE | Total number of papers (P) | Total number of citations (C) | Average citations per paper (C/P) | Average citations per year | Hirsch-index (h) | g-index (g) |
|---|---|---|---|---|---|---|
| $P_1$ | 168 | 727 | 4.32 | 21.38 | 12 | 19 |
| $P_2$ | 101 | 558 | 5.52 | 19.93 | 12 | 19 |
| $P_3$ | 55 | 354 | 6.43 | 18.63 | 10 | 15 |
| $C_1$ | 56 | 161 | 2.87 | 14.64 | 7 | 10 |
| $C_2$ | 66 | 91 | 2.11 | 3.33 | 6 | 9 |
| $C_3$ | 40 | 66 | 2.44 | 1.50 | 6 | 8 |

As for the number of published papers, the average European standard is 1 paper per year per researcher [20]. The visibility of Romanian research is particularly due to the

fundamental research carried out in the domains of basic sciences: physics, chemistry and mathematics [21-23], these being the only domains in which the scientific output is comparable with European indicators.

The mean number of citations per paper differs a lot from domain to domain. For example, in the year 2004 a mean of 2.16 citations was calculated for clinical medicine, 5.21 citations for molecular and genetic biology, 4.16 citations for immunology [24]. The number of citations per article in the domain of chemistry was found to be 2.9, while physics has 3.0, materials' science 1.2 and mathematics 0.95 [25, 26]. Should we consider these data, we could consider that the values presented in Table 3 are within the limits of European standards.

The Hirsch index is a simple and accurate measurement that simultaneously determines both the number of papers published by a researcher and the number of citations received by those papers. This index bears the name of the American physicist of Argentinean origin, Jorge Hirsch who is a professor of Physics at the University of San Diego, US, and resulted from the latter's frustration with the criticism made on the BCS Theory (Bardeen – Cooper – Schrieffer) regarding the superconductivity at relatively high temperature which had been given a cold welcome by the scientific community [27].

The Hirsch index is used for the evaluation and classification of scientific research institutes [28], universities [29, 30], academic journals [31], some countries' scientific output [32, 33], medical activity [34], certain specialists' performance [35] and so on. The Hirsch index determination is made manually [6] or automatically, by means of certain databases such as Web of Knowledge or Scopus.

Table 3 shows that the Hirsch index in the analyzed instance (h=6÷12) is honorable at European scale and good on a national plane, being comparable with the one existing in other scientific research institutions [36]. The National Authority for Scientific Research chairperson at present has an h = 2 [37]. The g index, also shown in Table 3, is an indicator proposed by Leo Egghe [19] for quantifying scientific productivity; it is calculated on the basis of the contribution of citations received by a researcher's papers. The g index calculation method can be seen from the data presented in Table and Fig. 1.

**Table 4. The g index calculation for P1.**

| | Citations per each paper | Order of papers | Cumulative number of citations | Square order of papers | |
|---|---|---|---|---|---|
| | 39 | 1 | 39 | 1 | |
| | 38 | 2 | 77 | 4 | |
| | 36 | 3 | 113 | 9 | |
| | 35 | 4 | 148 | 16 | |
| | 26 | 5 | 174 | 25 | |
| $h_{core}$ | 23 | 6 | 197 | 36 | |
| | 17 | 7 | 214 | 49 | |
| | 16 | 8 | 230 | 64 | |
| | 15 | 9 | 245 | 81 | |
| | 14 | 10 | 259 | 100 | $g_{core}$ |
| | 13 | 11 | 272 | 121 | |
| | **12** | **12** | 284 | 144 | |
| | 11 | 13 | 295 | 169 | |
| | 11 | 14 | 306 | 196 | |
| | 11 | 15 | 317 | 225 | |
| | 10 | 16 | 327 | 256 | |
| | 10 | 17 | 337 | 289 | |
| | 10 | 18 | 347 | 324 | |
| | 10 | **19** | **357** | **361** | |
| | 9 | 20 | 366 | 400 | |
| | 8 | 21 | 374 | 441 | |

| | | | |
|---|---|---|---|
| 8 | 22 | 382 | 484 |

Therefore, the g index of a number of papers listed in a decreasing order of the number of citations received is the highest number of papers in this arranged order that have received together $g^2$ citations. This results in g ≥ h. Burrell [38] points out that the I index reveals the most productive core of some authors, namely the most frequently cited papers. Rousseau [39] introduces the new term of "Hirsch core" (**h-core**). The g core can be seen in Table 4.

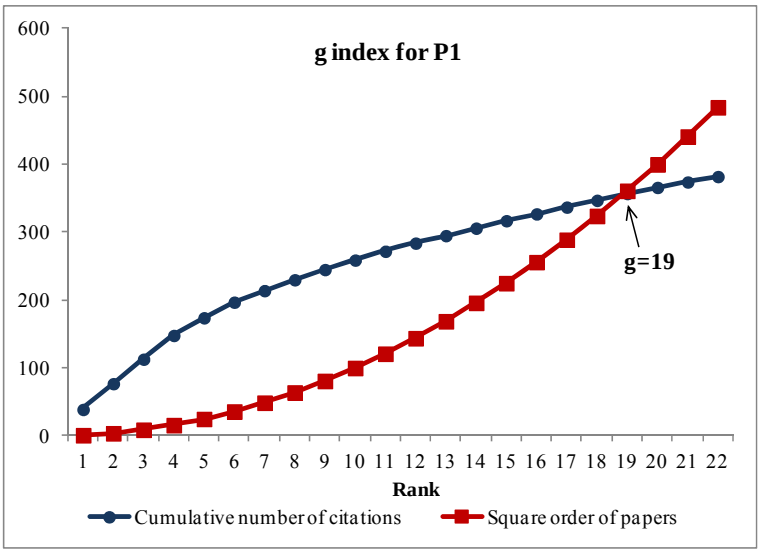


**Fig. 1. The graphic determination of the g index for P1.**

The *g* indices values presented in Table 3 are in full concordance with the values resulted from the type gvs.h correlations made by Lee et.al [40] and Schreiber [41] respectively.

Costas and Bordons [42] show that the g index is more sensitive than the Hirsch index in the selection of researchers. However, the Hirsch index remains a basic scientometric indicator for the determination of the scientific performance in the academic world. On the basis of this index (made up of three figures), they drew up a list of American chemists. The first positions on the list are taken by the organic chemistry professors Whiteside M. George ($h$ = 169) and Corey Elias James ($h$ = 140) from Harvard University (Figs. 2 and 3), the latter being a Nobel Prize Laureate [43, 44]. Romanian performances are still far away from those mentioned above, even the academic ones. A Romanian scientist, a biologist, Laureate of the Nobel Prize whose Hirsch index was high ($h$ = 105) was George Emil Palade [45].

The values of the straight lines slopes in Figs. 2 and 3 show the scientific productivity of the two outstanding researchers. The slope ratio reveals that Whitesides is more active than his eminent colleague.

As pointed out in a previous paper [7] the literature offers a large range of calculation relationships for the Hirsch index. Continuing the presentation and testing of such similar calculation relationships based on the total number of citations ($C$) and total number of papers ($P$) (see Table 1) we have obtained the results listed in Table 5.

The data recorded in Table 5 show that some results, relatively close to the Hirsch method, have been obtained. Figs. 4 and 5 present the correlations of these indices with the Hirsch index. It can be seen that the straight lines in Figs. 4 and 5 are obtained with correlation coefficients of 0.99.

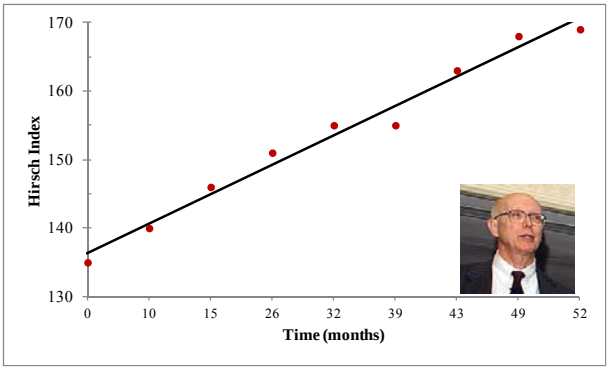


**Fig. 2. The Hirsch index dependency on time for the American Professor of Organic Chemistry, Whitesides G. M.**

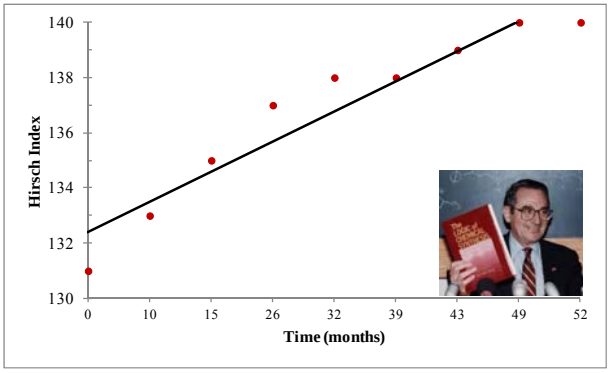


**Fig. 3. The Hirsch index dependency on time for the American Professor of Organic Chemistry, Corey E. Y. Nobel Prize Laureate.**

**Table 5. The Hirsch indices for the Chemistry Department academics calculated by various calculation relationships given in the literature.**

| Code | Total number of citations (*C*) | Total number of papers (*P*) | Hirsch index (*h*) according to: | | | | |
|---|---|---|---|---|---|---|---|
| | | | [10, 11] | [12] | [13, 14] | [15-17] | [5] |
| $P_1$ | 727 | 168 | 11.91 | 13.98 | 15.36 | 13.48 | 12 |
| $P_2$ | 558 | 101 | 10.99 | 12.31 | 13.46 | 11.81 | 12 |
| $P_3$ | 354 | 55 | 9.39 | 9.90 | 10.72 | 6.40 | 10 |
| $C_1$ | 161 | 56 | 6.32 | 6.84 | 7.23 | 6.34 | 7 |
| $C_2$ | 91 | 66 | 4.66 | 5.26 | 5.43 | 4.76 | 6 |
| $C_3$ | 66 | 40 | 4.22 | 4.56 | 4.63 | 4.06 | 6 |

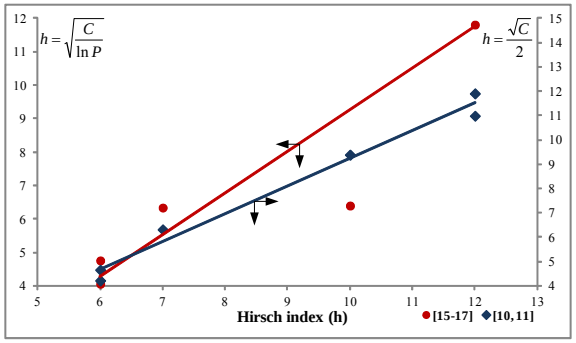


**Fig. 4. Correlations of some Hirsch-type indicators calculated from relationships proposed in papers [10, 11] and [15-17] with the Hirsch values obtained from ISI Web of Knowledge.**

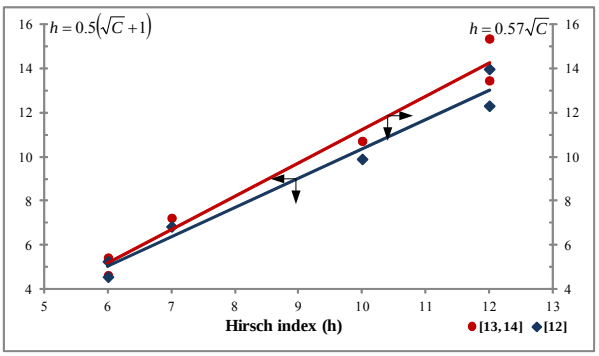


**Fig. 5. Correlations of some Hirsch-type indicators calculated from relationships proposed in papers [12] and [13, 14] with the Hirsch values obtained from ISI Web of Knowledge.**

The new indices suggested by Aliguliyev and Hasanova [18] for the determination of the researchers' scientific productivity has been tested for the academic members of the Chemistry Department. These represent the average square root as well as the arithmetic, geometric and harmonic mean of the Hirsch index (h) and of the median number of the citations received by the papers in the Hirsch core (m). The results that have been obtained are presented in Table 6.

**Table 6. The new indices proposed by Aliguliyev and Hasanova [18] to determine the researchers' scientific productivity.**

| Code | Hirsch index (h) | m-INDEX (the median number of citations) | $R_{hm}$ | $A_{hm}$ | $G_{hm}$ | $H_{hm}$ |
|---|---|---|---|---|---|---|
| $P_1$ | 12 | 24 | 18.97 | 18.00 | 16.97 | 16.00 |
| $P_2$ | 12 | 24 | 18.97 | 18.00 | 16.97 | 16.00 |
| $P_3$ | 10 | 15 | 12.74 | 12.50 | 12.24 | 12.00 |
| $C_1$ | 7 | 11 | 9.21 | 9.00 | 8.77 | 8.55 |
| $C_2$ | 6 | 8 | 7.07 | 7.00 | 6.92 | 6.85 |
| $C_3$ | 6 | 9 | 6.00 | 6.00 | 6.00 | 6.00 |

According to the authors, the obtained values illustrate the existence of three types of researchers and that is: Type I for whom h and m coincide, Type II where the two indices are different and Type III where there is a lot of difference between the two indices. The three types can be also seen in the data given in Table 6. At the same time it can be observed that:

$$\mathbf{m > R_{hm} > A_{hm} > G_{hm} > H_{hm} > h}$$

We should also notice that the new indices provide a value homogeneity of these indices, which results in a balanced perspective on a researcher's scientific productivity.

Figs. 6 and 7 show the correlation between the new indices and the Hirsch index (correlation coefficient: 0.99).

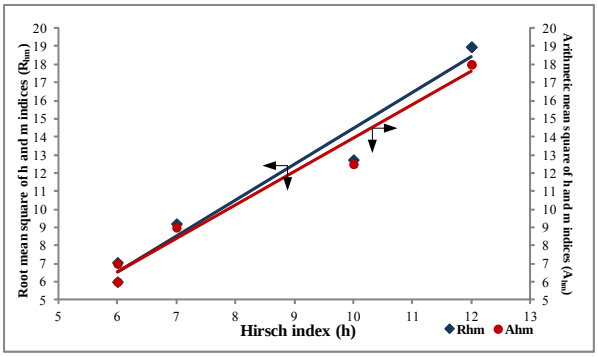


**Fig. 6. Correlation between $R_{hm}$ and $A_{hm}$ indices and the Hirsch index.**

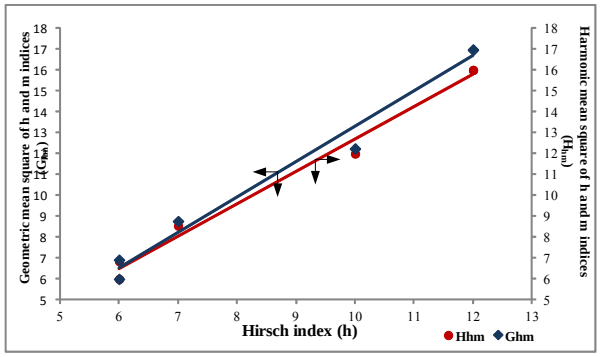


**Fig. 7. Correlation between $G_{hm}$ and $H_{hm}$ indices and the Hirsch index.**

## CONCLUSIONS

In this paper, we have applied new scientometric measurements that are described in literature in order to determine the scientific output of the Chemistry Department academic members. The result obtained following the use of these parameters does not modify the ascending line of the department members' scientific performance.

All the indicators that have been analyzed show the existence of some performances, comparable with the European standards, for most of the Chemistry Department academics.

The UVT Chemistry Department has always been a basic component in obtaining remarkable performances for the Valahia University of Targoviste and the Ad-Astra statistics demonstrate this.

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