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THE EVALUATION OF THE SCIENTIFIC OUTPUT OF RESEARCHERS

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1. Introduction

The evaluation of the scientific output of researchers by means of the computation of bibliometric measures has attracted significant interest, different measures and indices have been developed at this level of analysis [1,2,3]. In the last five years, the scientific community has paid a lot of attention to a new index, introduced by Hirsch in 2005 and called the h-index. It presents several good properties (for example, it is simple to compute and it takes into account both the quantity and impact of the publications) [4].

Burrell points out that the h-index identifies the most productive core of an author's output in terms of the most cited papers [5]. Rousseau introduced the term *Hirsch core* (h-core) [6].

***h*-index:** *A scientist has index h if h of his or her papers have at least h citations each, and the other ($N_p - h$) papers have $\leq h$ citations each.*

It is clearly, that $h \leq c(h)$, $h+1 > c(h+1)$, $c(h)$ – is the number of citations to the h th article.

The main advantage of the Hirsch index is that it combines a measure of quantity and impact in a single indicator. The second advantage of this index is that it is quite simple to compute from the citation data available through the ISI Web of Science of the ISI Web of Knowledge.

But the h-index has some drawbacks [7]. To overcome these issues, several authors have proposed several variants of the h-index. For example, A-index is defined as the average number of citations of papers in the Hirsch core [5], AR-index takes into account not only the citation intensity in the Hirsch core but also makes use of the age of the publications in the core [8].

Taking into account the Hirsch core and according to the results of the analysis developed by Bornmann et al. [7] two types of indices can be assumed: quantitative and qualitative indices. The first type of indices describes the most productive core of the output of researcher and inform about the number of papers in Hirsch core [9]. For example, the h-index [4], g-index [10], hg-index [11] and $h^{(2)}$-index [12]. The second type of indices depicts the impact of the papers in the core. For example, the a-index [13], m-index [7], ar-index [8], h_w-index [14].

The aim of this paper is to define new indices to characterize the scientific output of researchers (A_{hm}-, R_{hm}- and H_{hm}-index). These indices are based on the arithmetic, root square and harmonic means of an index describing the number of papers, h-index, and an index depicting the impact of the papers specifically, the median number of citations received by papers in the h-core – the m-index.

2. Preliminaries: *h*- and *m*-indices

One of the h-related indices that has got more attention is the called g-index. This index, presented by Egghe in 2006 was designed to provide more importance to the most cited papers of the author, as in the case h-index, it does not matter if a paper has more than h cites when computing the measure [10,15].

***g*-index:** *A set of papers has a g-index g if g is the highest rank such that the top g papers have, together, at least g^2 citations.*

***A* (average)-index:** *The A-index calculates the average number citations in the Hirsch core:*

$$A = \frac{1}{h}\sum_{i=1}^{h} cit_j ,$$

where, h – Hirsch index, cit_j – the number of citations to the j th paper [11,12].

As the distribution of citation counts is usually skewed, the median and not the arithmetic average should be used as the measure of central tendency. Therefore, as a variation of the A-index, it is proposed the m-index – the median number of citations received by papers in the Hirsch core.

***m*-index:** *The median number of citations received by papers in the Hirsch core. This is the papers ranking smaller than or equal to h.*

It is easy to prove that $m \geq h$.

***q^2*-index:** *The q^2-index of a researcher is computed as the geometric mean of his or her h- and m-indices, that is:*

$$q^2 = \sqrt{h \cdot m}$$

It is trivial to demonstrate that $h \leq q^2 \leq m$ [4].

3. New indices to characterize scientific output of researchers

Using mean values it can be described the variation forms of the h- and m-indices as following:

1. $R_{hm} = \sqrt{\frac{h^2 + m^2}{2}}$ – the root mean square of h- and m-indices;
2. $A_{hm} = \frac{h+m}{2}$ – the arithmetic mean of h- and m-indices;
3. $G_{hm} = \sqrt{h \cdot m}$ – the geometric mean of h- and m-indices; (this index is already defined as q^2-index [10]);
4. $H_{hm} = \frac{2hm}{h+m}$ – the harmonic mean of h- and m-indices;

It is clearly, that $h < R_{hm} < A_{hm} < G_{hm} < H_{hm} < m$.

4. Comparison

For comparison the new indices below are computed R_{hm}, A_{hm}, G_{hm} and H_{hm} -indices using h- and m-indices of the researchers ***A, B*** and ***C*** (Table 1). For clearness have taken three realizable cases (I – when prices of h- and m- indices are coincide, II – when prices of h- and m- indices less differ from each other, III – prices of h- and m- indices completely differ from each other):

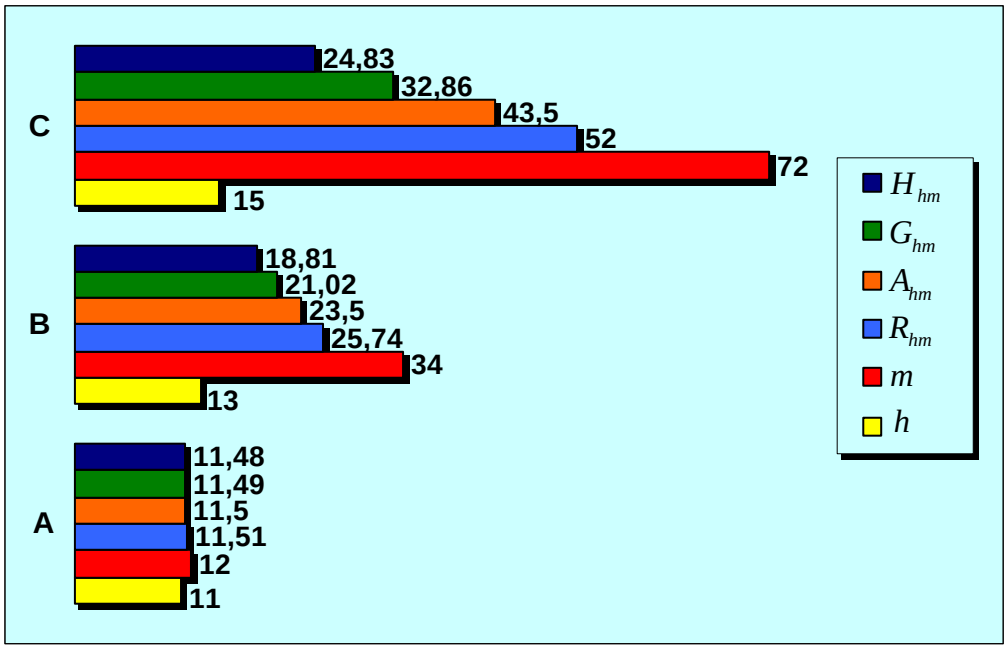
Table 1

	h	m	R_{hm}	A_{hm}	G_{hm}	H_{hm}
A	11	12	11,51	11,5	11,49	11,48
B	13	34	25,74	23,5	21,02	18,81
C	15	72	52	43,5	32,86	24,83

According to the values in the table we can say that when the values h- and m-indices are nearly, then R_{hm}, A_{hm}, G_{hm} and H_{hm} indices prices coincide.

Below it is shown difference between these indices, and it is clearly that the harmonic mean is near to the h-index, the square mean root is near to the m-index (Figure 1).

Figure 1



5. Conslusions

In this paper, have been presented new indices, called A_{hm}-, R_{hm}- and H_{hm}-index, which are based on the h- and m-indices and provide a more balanced view of the scientific output of researcher. We demonstrated the advantages of the proposed indices.

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