A time-dependent h-type indicator is proposed. This indicator depends on the size of the h-core, the number of citations received, and recent change in the value of the h-index. As such, it tries to combine in a dynamic way older information about the source (e.g., a scientist or research institute that is evaluated) with recent information.

Introduction

Since the introduction of the h-index in 2005 (Hirsch, 2005), many h-type indices have been proposed. In this short note, we propose yet another h-type index, which differs from other proposals in the way that it takes recent change in the value of the h-index into account. As such, we are convinced that this proposal is more useful for hiring purposes than the lifetime-achievement h-index.

For the reader’s convenience, we recall the definition of the h-index. Consider a scientist’s list of publications, ranked according to the number of citations received. Then this scientist’s h-index is defined as the highest rank such that the first h publications received each at least h citations. It is well-known that this definition can be applied to many more source-item relations than a scientist’s publications and citations. For simplicity, however, we use the original publication-citation terminology, but note that our proposal is applicable to most of these other relations. These first h articles form the h-core. The number of articles in the h-core and the list of citations received by articles in the h-core are always well-defined. As the h-index does not take the actual number of citations into account (i.e., it is just a cutoff point), several proposals have been published to make the h-index more sensitive to the real number of citations. Among these, we prefer the R-index proposed by Jin, Liang, Rousseau, and Egghe (2007), which is equal to the square root of the total number of citations received by articles belonging to the h-core (for more information about the h-index and its generalizations, refer to Bornmann & Daniel, 2007).

Rates of Change

Burrell (2007) considered two h-rates:

- The raw h-rate at Time $T$ is defined as $h(T)/T$, where $T = 0$ at the beginning of a scientist’s career or at another appropriate time, depending on the purpose of the study.
- The least squares h-rate at Time $T$ is defined as the slope of the least squares regression line constrained to pass through the origin for all pairs $[t, h(t)]$, $t = 0, \ldots, T$.

If the h-index increases linearly with career age, as suggested by Hirsch (2005), then these two h-rates are equal.

For further use, we define the h-increment at Time $T$ ($T > 0$) as

$$\Delta h(T) = h(T) - h(T - 1) \quad (1)$$

Assuming a continuous model $h(t)$ for the h-index, we further define the h-velocity at Time $T$ as:

$$v_h(T) = \frac{dh}{dt}(T) = \lim_{t \to 0} \frac{h(T + t) - h(T)}{t} \quad (2)$$

If $h(t)$ is a linearly increasing function of $t$, say $h(t) = m \cdot t$ ($m > 0$), then Burrell’s h-rate is equal to $m$, the increment...
The Rational h-Index (Ruane & Tol, 2008)

This index, denoted as \( h_{\text{rat}} \), is defined as \( (h+1) \) minus the relative number of scores necessary for obtaining a value \( h+1 \). It clearly satisfies the inequality \( h \leq h_{\text{rat}} < h+1 \). More precisely, let \( n \) be the (least) number of citations necessary for obtaining an h-index \( 1 \) higher than \( h \). This number \( n \) is divided by the highest possible \( n \)—namely, \( 2h+1 \). Indeed, the lowest possible situation leading to an h-index equal to \( h \) consists of \( h \) articles with \( h \) citations, followed by an article without any citation. To get an h-index equal to \( h+1 \), one needs one more score for each of the first \( h \) sources, \( h \) scores in total, and \( h+1 \) scores for the last one: a total of \( 2h+1 \). This h-index has the advantage of increasing in smaller steps than the standard h-index. It will play a role in our proposal for a dynamic h-type index.

A Dynamic h-Type Index

We propose an index which depends on the h-core, the actual number of citations received by articles belonging to the h-core, and the recent increase in \( h \). The definition contains three time-dependent elements: the size and contents of the h-core, the number of citations received, and the h-velocity. It is indeed possible that two scientists have the same h-index and the same number of citations in the h-core, but that one has no change in his h-index for a long time while the other scientist’s h-index is on the rise. For hiring purposes, the second scientist is probably the better choice.

Consequently, we propose

\[
R(T) \cdot v_{h}(T)
\]

as a dynamic h-type index. Here \( R(T) \) denotes the R-index (Jin et al., 2007), equal to the square root of the sum of all citations received by articles belonging to the h-core at Time \( T \). In practice, we have to determine a starting point, \( T = 0 \), and a way of determining \( v_{h} \). In our opinion, this starting point should not be the beginning of a scientist’s career, but when \( T \) is “now,” then \( T = 0 \) can be taken 10 or 5 years ago (or any other appropriate time). If one has a good-fitting continuous model for \( h(t) \) over this period, then this function should be used to determine \( v_{h}(T) \). In practice, it is probably better to find a fitting for \( h_{\text{rat}}(t) \) and not for \( h(t) \)—as this function is more similar to a continuous function than the standard h-index. Otherwise, the increment \( \Delta h_{\text{rat}}(T) = h_{\text{rat}}(T) - h_{\text{rat}}(T - 1) \) can be used (if it is not an obvious outlier). Note that when \( h_{\text{rat}}(t) \) is concave, this approximation will be larger than the real derivative; when \( h_{\text{rat}}(t) \) is convex, it will be smaller. When using this approximation, it is certainly appropriate to use the rational h-index as otherwise \( \Delta(h) \) will often be 0 or 1, and no meaning can be attached to these values. Note that Burrell’s raw h-rate \( h(T)/T \) should not be used as it is equal for all scientists with the same \( h(T) \), and hence, one loses the dynamic aspect. If Equation 3 is actually used for evaluating purposes, self-citations should be removed.

We claim that a period of “10 or 5 years,” as mentioned earlier, is appropriate; however, determining this period is not a “scientific” choice. After decades of experience, a consensus has grown that when using journal impact factors for evaluation purposes (not of individual scientists, but for research groups), a period of 3 or 4 years is appropriate. Yet, even today the “official” Thomson Scientific impact factor uses 2 years of citations, and Thomson’s Essential Science Indicators use a 10-year period. Hence, “10 or 5 years” is just a suggestion; only many years of experience can substantiate it.

Some Practical Considerations

If two scientists have the same h-index at Time \( T \) and the same number of citations, then the one whose h-function is convex (over the period \([0,T]\)) is preferred to the one whose h-function shows a linear increase. Similarly, the one with a linearly increasing h-function is preferred to the one with a concave h-function. This is particularly true for a scientist whose h-function is given by Egghe’s (2007) model, as this function is concavely increasing.

An Application

Using data from the Web of Science the first author’s h-index, rational h-index and R-index from 2001 to 2008 (April 11) is determined (see Table 1). Author self-citations, but not article self-citations, were removed.

A best-fitting power function \( h_{\text{rat}} = a \cdot y^{b} \) was determined using nonlinear regression, leading to \( h_{\text{rat}} = 1.67 \cdot y^{0.801} \) \((R^{2} = 0.984)\). The \( R^{2} \) value indicates that this is a good fit. Its derivative is 1.338 \( y^{-0.199} \), and in the Year 7 (2008),

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>h-index</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>( h_{\text{rat}} )</td>
<td>0.00</td>
<td>1.67</td>
<td>2.60</td>
<td>3.86</td>
<td>5.82</td>
<td>5.91</td>
<td>6.92</td>
<td>7.87</td>
</tr>
<tr>
<td>( R_{\text{index}} )</td>
<td>0.00</td>
<td>1.41</td>
<td>2.24</td>
<td>4.58</td>
<td>6.71</td>
<td>7.87</td>
<td>10.15</td>
<td>10.91</td>
</tr>
</tbody>
</table>

the value of this derivative is 0.91. Hence, R.R.’s dynamic h-index in the 2008 is equal to $(10.91) \cdot (0.91) = 9.93$. Using the approximation $\Delta h_{rat}(T) = h_{rat}(T) - h_{rat}(T - 1)$ for $h_{rat}(7)$ yields $7.87 - 6.92 = 0.95$, which should be compared with 0.91.

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