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Short communication

## The citation speed index: A useful bibliometric indicator to add to the *h* index

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### ABSTRACT

The scientific impact of a publication can be determined not only based on the number of times it is cited but also based on the citation speed with which its content is noted by the scientific community. Here we present the citation speed index as a meaningful complement to the *h* index: whereas for the calculation of the *h* index the impact of publications is based on number of citations, for the calculation of the speed index it is the number of months that have elapsed since the first citation, the citation speed with which the results of publications find reception in the scientific community. The speed index is defined as follows: a group of papers has the index *s* if for *s* of its  $N_p$  papers the first citation was at least *s* months ago, and for the other  $(N_p - s)$  papers the first citation was  $\leq s$  months ago.

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### 1. Introduction

According to Dalen and Henkens (2005), the scientific quality of a publication can be determined not only based on the number of citations but also based on citation speed:

The quality of articles ... is approximated by the *impact* and *speed* with which knowledge is disseminated in the scientific community ... The reason why the chances of a first citation decrease over time may be that observed uncitedness of articles signals to prospective readers that the article is of low quality. In other words, uncitedness may become a stigma and the longer an article remains uncited, the lower the perceived quality of the article. (pp. 210–211)

The citation speed measure was introduced by Schubert and Glänzel (1986) as a meaningful addition to the bibliometric toolkit. In Bornmann and Daniel (2010) we tested whether manuscripts that were accepted by *Angewandte Chemie International Edition* (AC-IE, one of the prime chemistry journals worldwide) received the first citation after publication faster than manuscripts that were rejected by the journal but published elsewhere. The results of a Cox regression model showed that accepted manuscripts have a 49% higher hazard rate of citation than rejected manuscripts.

In this paper, following the *h* index (Bornmann & Daniel, 2007, 2009; Hirsch, 2005) we present a new indicator for research performance – the citation speed index. Whereas the *h* index refers to those publications in a publication set that have a certain minimum number of citations, the citation speed index describes those publications in a publication set whose first citation was made a certain minimum time period ago.

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**Table 1***h* index and citation speed index for accepted manuscripts (and published in AC-IE) and rejected (but published elsewhere) manuscripts.

Index	Accepted manuscripts	Rejected, but published elsewhere manuscripts
<i>h</i> index		
All manuscripts ( $n = 1837$ )	70	53
Manuscripts published in 2000 ( $n = 782$ )	61	36
Manuscripts published in 2001 ( $n = 888$ )	52	44
<i>Citation speed index</i>		
All manuscripts ( $n = 1832$ )	75	70
Manuscripts published in 2000 ( $n = 780$ )	75	70
Manuscripts published in 2001 ( $n = 887$ )	67	66

Note. The *h* index was calculated based on citation counts searched in Thomson Reuters' Science Citation Index. The citations were in the period from publication up to January 1, 2007.

## 2. Data and methods

### 2.1. Database for the present study

For this study we used bibliometric data for 1899 manuscripts that were submitted to AC-IE. Of the 1899 manuscripts that were reviewed by the AC-IE in the year 2000, 46% ( $n = 878$ ) were accepted for publication in AC-IE, and 54% ( $n = 1021$ ) were rejected. A search in the literature databases Science Citation Index (SCI, Thomson Reuters) and Chemical Abstracts (CA, Chemical Abstracts Services, CAS, Columbus, OH) revealed that of the 1021 rejected manuscripts, 959 (94%) were published later in 136 other (different) journals. For accepted and rejected (but published elsewhere) manuscripts, we determined – in addition to the number of citations – the number of months since the first time the paper was cited and when the search was done (January, 2007). The searches were done using Web of Science (WoS, Thomson Reuters).

### 2.2. Construction of the citation speed index

The citation speed index is defined as follows: a group of papers has the index  $s$  if for  $s$  of its  $N_p$  papers the first citation was at least  $s$  months ago, and for the other  $(N_p - s)$  papers the first citation was  $\leq s$  months ago. In this study the index was calculated based on the number of months from the first citation to the time point of the search. A period of  $s$  ( $s \geq 1$ ) months means that the first citation was made more than or equal to  $s$  months ago but less than  $s + 1$  months ago.

For five manuscripts in the data set, there was no first citation at the time point of the search.

## 3. Results

First, we calculated the *h* index for the group of accepted and for the group of rejected (but published elsewhere) manuscripts. The results are shown in Table 1. When all manuscripts in all groups are included, the *h* index value for accepted manuscripts is 70 and the *h* index value for rejected (but published elsewhere) manuscripts is 53. This means that as measured by the *h* index, accepted manuscripts show clearly better performance than rejected (but published elsewhere) manuscripts. As the number of citations for a manuscript depends on the size of the citation window and as in the data set of this study (mainly for rejected manuscripts) the citation window varies, Table 1 shows the *h* index separately for manuscripts that were published in the year 2000 or 2001 (approximately 90% of all manuscripts were published in these 2 years; the remaining 10% were published from 2002 to 2006). Also the separate calculations show that the *h* index is clearly higher for accepted manuscripts than for rejected manuscripts.

In addition to the *h* index values, Table 1 also shows citation speed index values for accepted and rejected (but published elsewhere) manuscripts. When all manuscripts in the data set are included, the citation speed index value for accepted manuscripts is 75 and the citation speed index value for rejected manuscripts is 70. That means that for 75 accepted manuscripts the first citation was made at least 75 months ago, for 70 rejected (but published elsewhere) manuscripts the first citation was made at least 70 months ago. This result indicates that the content of the accepted manuscripts was disseminated in the scientific community more quickly than the content of the rejected manuscripts. As not only the number of citations for a publication but also the period of time since the first citation depends significantly on the size of the citation window, Table 1 also provides the citation speed index values for manuscripts published in 2000 and 2001. Here again we find that in those 2 years, accepted manuscripts have a higher citation speed index value than rejected manuscripts (but the difference is only 1 month for 2001).

## 4. Discussion

In this study we presented the citation speed index, a variant of the *h* index that can be a meaningful complement to the *h* index: whereas the *h* index calculation considers the impact of publications, the citation speed index is a measure of the speed with which the content of publications is noted by the scientific community (that is, the number of months since the

first citation). For calculation of the citation speed index it would seem obvious to base it on the number of months from publication of a manuscript up to its first citation. That is not possible, however, because an  $h$  index variant can be used meaningfully as a performance measure only if increasing values are also associated with better performance.

Further empirical studies in different disciplines and based on larger data sets will be needed to test the validity of the citation speed index. Many of the disadvantages that have been discussed in connection with the  $h$  index and its variants surely apply to the citation speed index as well (see here the overview of Alonso, Cabrerizo, Herrera-Viedma, & Herrera, 2009; Panaretos & Malesios, 2009). In this study, for example, we included self-citations in the search for a publication's first citation, because it is not expected that the occurrence of a self-citation as the first citation varies systematically for the accepted and rejected (but published elsewhere) manuscripts (Bornmann & Daniel, 2010). However, we assume that the citation speed index value will vary depending on the inclusion or non-inclusion of self-citations. As information on self-citations was not available for the manuscripts accepted or rejected (but published elsewhere) by AC-IE, this aspect should be examined in follow-up studies.

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