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The h-index and its variants: which works best?

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Despite these trends in article output, the SEI 2008 report demonstrates that the US continues to produce the best-cited research in the world, as indicated by its dominant share of articles in the top 1% of cited articles across all fields. This finding is borne out by comparing the **h-index** of the US with those of selected world regions (see Figure 3).

By any measure, the US remains the world's dominant scientific nation. The question facing government policymakers in the age of knowledge-based economies is: for how much longer?

References:

(1) Hill, D., Rapoport, A.I., Lehming, R.F., and Bell, R.K. (2007) "Changing U.S. output of scientific articles: 1988–2003", National Science Foundation special report.

(2) "Science and Engineering Indicators 2008", National Science Board report.

(3) "Research and Development: Essential Foundation for U.S. Competitiveness in a Global Economy", National Science Board report.

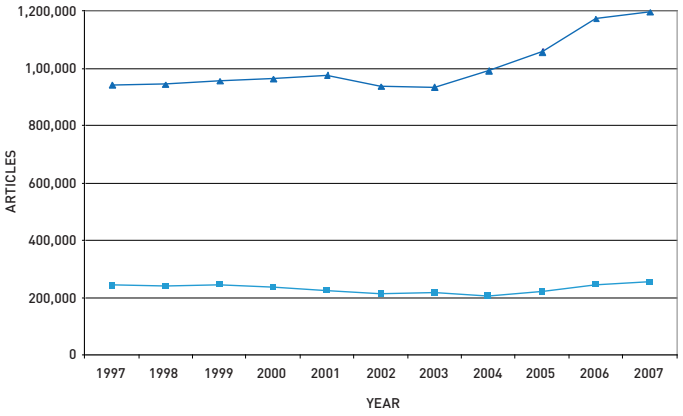

Figure 2 – Number of articles published by US researchers (light blue) versus world (dark blue), 1997–2007. Source: Scopus

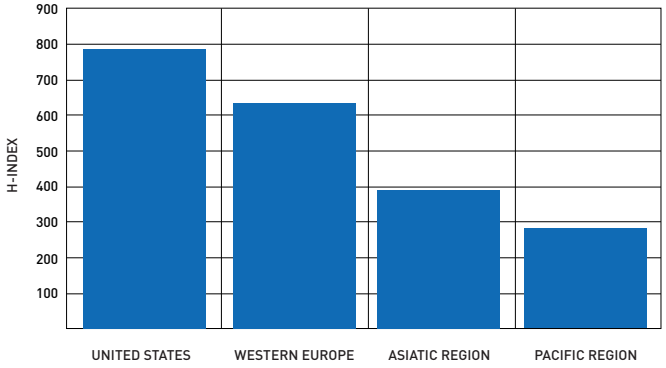

Figure 3 – H-index of US versus selected global regions. Here, the h-index defines the number of documents published in the period 1996–2006 that receive the same or greater number of citations during the same period. Source: **SCImago SJR – SCImago Journal & Country Rank**

Expert opinion

The h-index and its variants: which works best?

Dr. Lutz Bornmann

The h-index was originally proposed by Jorge Hirsch in 2005 to quantify the scientific output of an individual researcher. It was conceived as an improvement on previous indices, which tended to focus on the impact of the journals in which the researcher had published, and so assumed that the author's performance was equivalent to the journal's average. If a scientist's publications are ranked in order of the number of lifetime citations they have received, the h-index is the highest number, h, of their papers that have each received at least h citations.

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Room for improvement

The **h-index** quickly gained widespread popularity. This is largely due to the fact that it is conceptually simple, easy to calculate and gives a robust estimate of the broad impact of a scientist's cumulative research, explains Dr. Lutz Bornmann, post-doctoral researcher active in bibliometrics, scientometrics and peer-review research at ETH Zurich, the Swiss Federal Institute of Technology *(1)*.

However, the h-index has received some criticism, most notably:

- It is not influenced by citations beyond what is required for entry to the h-defining class. This means that it is insensitive to one or several highly cited papers in a scientist's paper set, which are the papers that are primarily responsible for a scientist's reputation.
- It is highly dependent on the length of a scientist's career, meaning only scientists with similar years of service can be compared fairly.
- A scientist's h-index can only rise (with time), or remain the same. It can never go down, and so cannot indicate periods of inactivity, retirement or even death.

Variants of the h-index that have been developed in an attempt to solve one or more of its perceived shortcomings include the m-quotient, **g-index**, h(2)-index, a-index, m-index, r-index, ar-index and h_w-index. Hirsch himself proposed the m-quotient, which divides the h-index by the number of years a scientist has been active, thereby addressing the problem of longer careers correlating with higher h scores.

Two types of index

For Bornmann, the value of a bibliometric index lies in how closely it predicts the results of peer assessment. In a paper published in the *Journal of the American Society for Information Science and Technology*, of which he was co-author *(1)*, he analyzed nine indices to find out whether any has improved upon the original h-index, with particular focus on their ability to accurately predict peer assessment.

He discovered that there are two basic types of index: those that better represent the quantity of the productive core (defined as the papers that fall into the h-defining class), and those that better represent the impact of the productive core (see sidebar). In a further study to validate these findings, Bornmann tested his results against 693 applicants to the Long-Term Fellowship program of the European Molecular Biology Organization, Heidelberg, Germany. The study confirmed these two basic types.

Quantity versus impact

1. Quantity of the productive core: the h, g and h(2) indices and the m-quotient describe the productive core of a scientist's output and show the number of papers in the core.

2. Impact of the productive core: the a, m, r, ar and h_w indices show the impact of papers in the core. This is closer to peer-assessment results.

This is useful, as the indices that better represent the impact of the productive core agree with the opinions of the applicants' peers. "The results of both studies indicate that there is an empirical incremental contribution associated with some of the h-index variants that have been proposed up to now; that is, with the variants that depict the impact of the papers in the productive core," Bornmann says.

A balanced approach

Several researchers in the field have suggested that bibliometricians would do well to use several indices when assessing a scientist's output and impact. Bornmann agrees, adding that the results of his research indicate that the best way to combine the different indices is to ensure that one chooses an index from each category.

"After analysis of all indices, matching the results to the real results of peer assessment, using two indices – one to measure output and another to measure impact – is the closest to peer-assessment results," he explains. "In the future, we definitely need fewer h-index variants and more studies that test their empirical application with data sets from different fields."

Dr. Bornmann's full paper can be found **here**.

Reference:

(1) Bornmann, L., Mutz, R., and Daniel, H.D. (2008) "Are there better indices for evaluation purposes than the h index? A comparison of nine different variants of the h index using data from biomedicine", *Journal of the American Society for Information Science and Technology*, Vol. 59, No. 5, pp. 830–837.