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Total influence and mainstream measures for scientific researchers

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ABSTRACT

We propose two new indices that are able to measure a scientific researcher's overall influence and the level of his/her works' association with the mainstream research subjects within a scientific field. These two new measures – the total influence index and the mainstream index – differ from traditional performance measures such as the simple citation count and the *h*-index in that they take into account the indirect influence of an author's work. Indirect influence describes a scientific publication's impact upon subsequent works that do not reference it directly. The two measures capture indirect influence information from the knowledge emanating paths embedded in the citation network of a target scientific field. We take the Hirsch index, data envelopment analysis, and lithium iron phosphate battery technology field to examine the characteristics of these two measures. The results show that the total influence index favors earlier researchers and successfully highlights those researchers who have made crucial contributions to the target scientific field. The mainstream index, in addition to underlining total influence, also spotlights active researchers who enter into a scientific field in a later development stage. In summary, these two new measures are valuable complements to traditional scientific performance measures.

1. Introduction

There exist three quantitative method categories to measure the performance of a scientific researcher. The first category, the simple-count method, simply counts a researcher's number of publications. The method was adopted in a number of studies looking at the effect of research collaboration on scientific productivity (Abramo, D'Angelo, & Costa, 2009; Landry, Traore, & Godin, 1996; Lee & Bozeman, 2005; Ynalvez & Shrum, 2011). The second category, the citation-count method, counts the number of citations of a researcher's publications. This method has a long tradition of being used by the research community ever since Garfield (1963) proposed the concept of the citation index. The Hirsch index (Hirsch, 2005) belongs to the third category and counts the number of citations and the number of publications at the same time for a researcher. More than twenty variants of the Hirsch index were proposed (Egghe, 2010; Schreiber, 2010) after Jorge Hirsch put forward the index in 2005. Many studies on the correlation between collaboration and scientific performance applied the Hirsch-type index method (Abbasi, Altmann, & Hosssain, 2011; Pike, 2010).

Each of the above categories measures a scientific researcher's performance from a different perspective. The simple-count method measures a researcher's publishing productivity. 'Output' and 'productivity' are the terminologies commonly associated with the simple-count method. The citation-count method assesses how well a researcher's publications were recognized or aware of by other researchers and is often attached with the terms 'impact' and 'influence'. The Hirsch-type index evaluates a researcher's productivity and visibility at the same time. Although the original Hirsch article (Hirsch, 2005)

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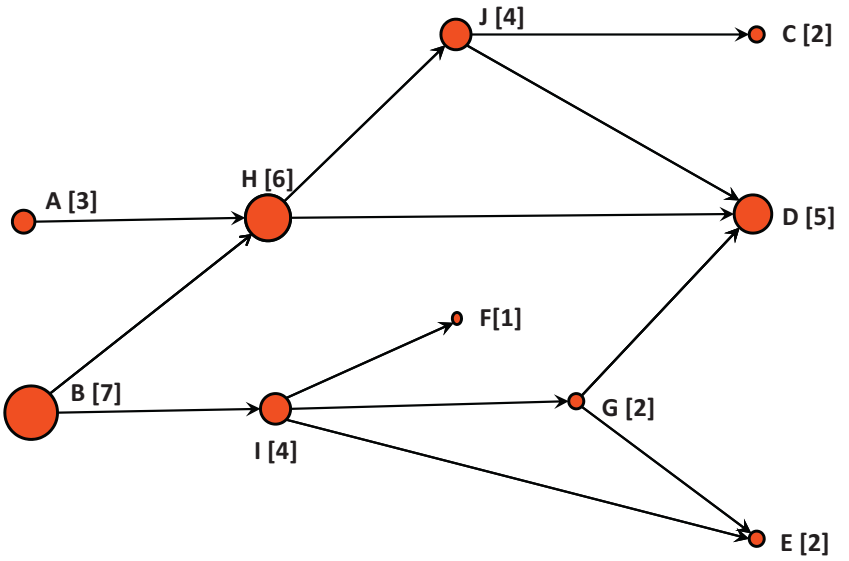

Fig. 1. A simple citation network. The numbers enclosed by the square brackets are the SPC values. Sizes of the nodes are proportional to their SPC values.

adopted the term 'research output', many other terminologies, such as 'performance', 'impact', and 'productivity', exist in the Hirsch-type index literature. It should be noted that for these measures to be meaningful they should be associated with a certain period and a specific scientific field.

Be it 'output', 'productivity', 'impact', 'influence', or 'performance', there is one performance aspect that all the existing measures do not cover—the indirect influence of scientific papers or researchers. Consider three papers A, B, and C, where paper C cites paper B, and paper B cites paper A. The influence of paper B on paper C is direct and obvious, whereas the influence of paper A on paper C is indirect and less obvious. The direct influence comes from the immediate citation one commonly observes. The indirect influence, however, originates from the concepts proposed a few steps back in the citation chain.

One peculiar issue of the Hirsch index is worth mentioning—the Hirsch index for Hirsch himself in the Hirsch index research field is relatively small. For example, the *h*-index and its variant *g*-index (Egghe, 2006) for Jorge Hirsch are both 3, a very small number. As a physicist, Hirsch himself published only three articles (Hirsch, 2005, 2007, 2010) related to the index he created. If one applies the Hirsch index as an indicator for scientific influence in the Hirsch index field, then Jorge Hirsch's influence is insignificant. Nevertheless, there should be no doubt that Jorge Hirsch has had a huge influence on the Hirsch index research field. This weakness of the Hirsch index originates from the fact that the index is artificially limited by publication counts.

This study proposes two new performance measures that can better reflect a scientific researcher's overall accomplishment than the existing measures mentioned above. They trace knowledge emanating paths and take into account not only the direct influence, but also the indirect influence of an author's work. Similar to the *h*-index, these two new measures – the total influence index and the mainstream index – gauge the publication quality of a researcher based on citation information.

The remaining portion of the article is organized as follows. The next section introduces the total influence index and the mainstream index in detail. Section 3 presents the new measures for scientific researchers in three scientific fields. These results are compared with that from the citation-count method and the Hirsch-index method. A conclusion is provided at the end.

2. The two new measures

The two new measures have one common characteristic—they both trace the knowledge diffusion paths of a researcher's works. When the publication of an author cites a work of his/her peer(s), then presumably the author considers the concepts in that work to have played a part in the paper he/she is now publishing. Certain knowledge is diffused from the cited work to the author's publication through a virtual knowledge conduit between the two publications. Knowledge can disseminate downward through the conduits for several generations. If a proposed idea inspires not only its immediate followers, but the followers' followers, then it will spawn several descending publications and the idea will emanate through a sequences of knowledge diffusion conduits. These sequences of knowledge conduits form the knowledge diffusion paths.

Knowledge diffusion paths can be easily visualized in a citation network. Fig. 1 is a simple citation network that includes 10 publications. In the figure, A–H–J–C, A–H–J–D, and A–H–D are knowledge diffusion paths beginning with A. It should be noted that knowledge flows from a cited publication to the citing publications. For example, publication H cites A so that