findings of the investigation dismissed research results from "high impact" papers that had been promoted as major breakthroughs in the field.

Active manipulation of IF

Owing to the preference authors and researchers give to high IF journals, editors may be tempted to artificially raise a journal IF. One very crude way to do so is by requesting author self-citation. In 1997, the journal *Leukemia* was accused of trying to manipulate its IF [37]. This first accusation came from Terry Hamblin, editor of *Leukemia Research*, a competitor to *Leukemia*. The evidence he was holding showed that *Leukemia* had asked authors who had submitted a paper to the journal to cite more articles from *Leukemia*. Later in 2002, Neuberger and Counsell [38] reported another similar case: they described how one journal editor suggested the inclusion of more references to that journal. In 2004, Sevinc [39] reported yet another incident. The influence of authors' choice of references distorts the perception of the journal within the scholarly community and is considered as highly unethical behavior.

Alternative journal impact measures

The wide use of the IF, combined with obvious flaws, has motivated researchers in scientometrics to try to improve the algorithm for the calculation of the IF or to develop alternative journal citation measures altogether.

Van Leeuwen and Moed [20] have critically analyzed the use and validity of the ISI IF. They focused on four aspects: "non-citable" items included in the numerator of the IF calculation; the relative distribution of research articles; technical notes and reviews, different citing behavior across subject fields; and the fixed two-year citation window. They developed an alternative journal impact measure, the *Journal to Field Impact Score* (JFIS), to provide solutions to biases incurred from these four aspects. The JFIS includes research articles, technical notes, letters and reviews both in the numerator and the denominator. The JFIS also is field-normalized by comparing the journal's impact with the citation average in the fields it covers. The JFIS takes into account the relative distribution among the four types of distribution. Finally, the JFIS is computed based on a flexible and variable citation and publication window, and the selected publication window can in principle be set to any length. Despite the improvements that the JFIS has over the IF, van Leeuwen and Moed still suggested that more than one indicator should be used in bibliometric journal impact measurements.

Other researchers have focused on refining the ISI IF's limitations, such as the fixed two-year chronologic window. Asai [40] found that more accurate statistics could be calculated if the period count is based on months rather than a year. Accordingly, he proposed an *Adjusted Impact Factor* to count a weighted sum of citations per month over a time period of four years. Glänzel and Schoepflin [41] conducted a bibliometric study to analyze the time behavior of citations to articles published in seven journals in different subject fields including social sciences, chemistry, medicine and mathematics. The results suggested a three-year citation window to be a good compromise between fast growing disciplines and slowly aging theories.

Sombatsompop et al. [42] introduced the cited half-life into the IF calculation as an alternative to setting the citation window at an absolute number. The proposed indicator, the *Cited Half-Life Impact Factor* (CHAL-IF), is calculated by replacing the two-year citation window with the journal's cited half-life in the IF computation formula. This study was based on 34 journals in the Polymer Science Category from the ISI subject heading categories. The journal ranking based on the CHAL-IF was different from that based on the ISI IF. The average IF by the CHAL method achieved a better stability than that calculated by the standard ISI method. Rousseau [43] renamed the CHAL-IF to *Median Impact Factor* (MIF). He further generalized the MIF to create a *Percentile IF* (pIF). The MIF is a special case of the pIF with p set at 50%. These modified IFs are not meant to replace the ISI IF, but should rather be understood as a complementary assessment tool.

When ranking a list of journals within a subject discipline, it is inadequate to only compare the IF without consideration of subject bias. Hirst [44] introduced what he called the *Disciplinary Impact Factor* (DIF) to overcome this subject bias. It is based on the average number of times a journal was cited in a sub-field rather than the entire SCI database. A similar approach was chosen by Pudovkin and Garfield [45], who suggested a rank normalized impact factor to be calculated within each subject category. For any journal j, its rnIF is designated as rnIF(j) and equals (K - R-j + 1)/K, where R-j is the descending rank of journal j in its JCR category and K is the number of journals in the category. Ramírez et al. [46] proposed a renormalized IF which was calculated based on the maximum IF and median IF of each category. This quantitative parameter allows the direct comparison among different research areas without introducing other considerations. Sombatsompop [47,48] introduced a new mathematical index, the "Impact Factor Point Average" with the specific aim to allow across-field comparison of IF.

The above-mentioned variants of the IF may improve journal citation methodological aspects. As of now, no database makes use of these derivative algorithms. They are neither widely known nor accessible to the scientific community. There are some commercial alternative data-