Journal of Informetrics 8 (2014) 241–251

Contents lists available at ScienceDirect

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi

# Technological impact factor: An indicator to measure the impact of academic publications on practical innovation

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ARTICLE INFO

*Article history:*
Received 16 August 2013
Received in revised form 6 December 2013
Accepted 9 December 2013
Available online 31 December 2013

*Keywords:*
Technological impact fact
Patent reference
Journal impact factor

ABSTRACT

This study established a technological impact factor (TIF) derived from journal impact factor (JIF), which is proposed to evaluate journals from the aspect of practical innovation. This impact factor mainly examines the influence of journal articles on patents by calculating the number of patents cited to a journal divided by the number of articles published in that particular journal. The values of TIF for five-year ($TIF_5$) and ten-year ($TIF_{10}$) periods at the journal level and aggregated TIF values ($TIF_{AGG\_5}$ and $TIF_{AGG\_10}$) at the category level were provided and compared to the JIF. The results reveal that journals with higher TIF values showed varied performances in the JCR, while the top ten journals on $JIF_5$ showed consistent good performance in TIFs. Journals in three selected categories – Electrical & Electronic Engineering, Research & Experimental Medicine, and Organic Chemistry – showed that $TIF_5$ and $TIF_{10}$ values are not strongly correlated with $JIF_5$. Thus, TIFs can provide a new indicator for evaluating journals from the aspect of practical innovation.



## 1. Introduction

It is important to identify the degree of importance of information as well as its impact in this era in which we are saturated in information. Due to time and financial constraints, bibliometric methods are often employed to retrieve high-value information. Developed by the founder of the Institute for Scientific Information (ISI), journal impact factor (JIF) is an indicator used to measure the impact of a specific journal and thus illustrate knowledge flow among papers (Garfield, 1995). A JIF value is calculated by first aggregating the citations received from other articles during a given time span to all articles published in a given journal during a given period and then dividing this aggregation by the number of articles published by the journal during that period. JIF indicates the degree of importance and impact of the dissemination of information to the scientific disciplines in which the journal is indexed, and has become an important indicator for evaluating the influence of a journal on scientific research. JIF has also been employed by librarians for journal selection and purchase. While JIF is calculated based on the citations received from journal articles, knowledge flows exist not only among scientific journal articles but also in other subjects, such as patents and the Web. Hence, many studies have examined the relationships among patents using patent citation analysis.

Scientific journal articles influence not only other scientific research, but also industrial research and development. Because a patent may refer to or credit a scientific article through its references, the concept of science linkage is proposed

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http://dx.doi.org/10.1016/j.joi.2013.12.004

to calculate the number of papers cited per patent in order to measure the impact of a scientific article on a certain patent. Building upon the concept of science linkage, technological impact factor (TIF), derived from the JIF method, is proposed as a new indicator for evaluating journals from the aspect of practical innovation and for examining the impact of scientific journals on patents. The practical application and limitations of the TIF will also be discussed in this study. TIF values for the five-year ($TIF_5$) and ten-year ($TIF_{10}$) periods are calculated for each category and journal indexed in the Journal Citation Report (JCR). Then, three categories were selected from the top 15 categories to examine the performance of journals in each category. In addition, the JIF for five years ($JIF_5$) of publication in JCR 2011 is presented in this study to compare with $TIF_5$ and $TIF_{10}$ values.

## 2. Literature review

### 2.1. Journal impact factor (JIF)

Journal impact factor (JIF) was first developed by Eugene Garfield. It is calculated using the Journal Citation Report (JCR) and now published by Thomson Reuters. The report covers more than 8000 journals in science and technology and more than 2600 journals in the field of social science (Thomson Reuters, 2012a, 2012b). The JIF is widely adopted in many disciplines. For example, librarians employ the JIF to select journals for library collections, and some studies have adopted JIF to measure the quality of research. For example, Glynn et al. (2012) adopted two-year JIF as an indicator to evaluate search yields within the laryngeal cancer field during the period from 1945 to 2010. Other medical-related studies also employed the JIF to evaluate the methodological and ethical quality of research in controlled trials in surgical research (Bridoux et al., 2012), with their results indicating that the JIF of a biomedical journal was directly related to the journal's ethical requirements for publication. Some studies examined the applicability of the JIF in particular fields. For instance, Saha et al. (2003) measured the quality of general medical journals and indicated that JIF was a reliable indicator for journal evaluation. Smith (2010) adopted the JIF to examine the impact factor trends of five selected core journals in occupational medicine, stating that citation data provides useful information on citation rates and publishing trends.

Despite the diverse implications of the JIF in evaluating academic performance, researchers have noticed that JIF varies across fields and over different timespans (Althouse, West, Bergstrom, & Bergstrom, 2009). The sizes of each category, which in the ISI are comprised of various sub-categories, are strikingly different. Moreover, citation behaviors and the nature of each discipline also vary across categories (Balaban, 2012; Garfield, 1999; Kokko & Sutherland, 1999; Moed, 2005a, 2005b; Sen, 1992; Sen & Shailendra, 1992). There are many arguments regarding the reliability of deploying JIF as an objective indicator for journal evaluation, despite the fact that the JIF is widely employed as an indicator for the selection of journals and the evaluation of the academic performance of individuals and institutions. Some studies have questioned the reliability of citations, the primary measurement unit of JIF, because not all citations mean to acknowledge previous studies (Balaban, 2012). Authors may cite an article to criticize or correct errors in that article. Other limitations, such as language bias, self-citation, and different sizes of research fields, have also been raised to argue against the applicability of the JIF. Furthermore, the number of citations received by each article is not consistent in different databases, such as JCR, Scopus, and Google Scholar.

Seglen (1997), Russell and Singh (2009), Dempsey (2009), and Lee and Lin (2013) mentioned some deficiencies in the JIF. First, these researchers found that the JIF was not statistically correlated to individual academic performance. Journals with high JIFs did not always publish papers in which authors received more citations. Conversely, authors that received large numbers of citations did not always submit their papers to high-impact journals. Second, review articles were generally highly cited, and different types of articles and journals receive varied numbers of citations. In addition, citations present a skewed distribution, in which a small number of journals receive most of the citations. Hence, it is questionable whether JIF can be used to compare the academic performance across journals. To improve the accuracy of the JIF, some studies have proposed alternative methods derived from the JIF. For example, Eigenfactor and Article Influence have been used to estimate the relative influence of articles based on cross-citation data (Bergstrom, West, & Wiseman, 2008). Some research articles have also proposed different indicators to evaluate the impact of journals. Bornmann, Marx, Yuri, & Gasparyan (2012) reviewed the limitations of the JIF alongside alternative metrics, such as SCImago Journal Rank, and the *h*-index. Leiden University adopted the Scopus database by Elsevier to provide CWTS journal indicators, with source normalized impact per paper (SNIP), the most well-known indicator (Centre for Science and Technology Studies, 2013).

### 2.2. Science–technology interaction

In the past, science and technology were often considered separate entities that rarely communicated with each other. Recently, science has played an important role in the development of technologies (Schmoch, 1997). Many studies have focused on the relationship between patents and papers (or journal articles). Academic papers can now contribute not only to the development of scientific theory, but also to the progress of economic activity (Narin, Hamilton, & Olivastro, 1997). In addition, Von Looy et al. (2003) indicated that the number of papers referenced in patents could be employed to examine the science intensity of a technology domain. To measure the impact of papers on patents, "science–technology interaction" and "science linkage", defined as the number of papers cited per patent, were proposed as measurements (Tamada, Naito, Kodama, Gemba, & Suzuki, 2006).