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EFFECT OF BIBLIOGRAPHICAL CLASSIFICATION ON THE IMPACT FACTOR OF SCIENCE- AND ENGINEERING-BASED JOURNALS

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The simplest and widely used assessment of academic research and researchers is the journal impact factor (JIF). However, the JIF may exhibit patterns that are skewed towards journals that publish high number of non-research items and short turnover research. Moreover, there are concerns as the JIF is often used as a comparison for journals from different disciplines. In this study, the JIF computation of eight top ranked journals from four different subject categories was analyzed. The analysis reveals that most of the published items (>65%) in the science disciplines were nonresearch items while fewer such items (<22%) were observed in engineering-based journals. The single regression analysis confirmed that there is correlation ($R^2 \geq .99$) in the number of published items or citations received over the two-year period used in the JIF calculation amongst the eight selected journals. A weighted factor computation is introduced to compensate for the smaller journals and journals that publish longer turnover research. It is hoped that the approach can provide a comprehensive assessment of the quality of a journal regardless of the disciplinary field.

Keywords: *bibliographical database, citation, impact factor, indexing*

Introduction

For academic research outcomes, there is an increasing emphasis on the bibliometric scoring when assessment of the quality of research is required (Hobbs, 2007). One of the most widely used measures is the journal impact factor (JIF) of the scientific publications (Adam, 2002; Garfield, 2006; Golubic et al., 2008; Hobbs, 2007). The JIF for a specific journal is computed as the number

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of citations in the scientific literature for articles published in the preceding two years divided by the number of citable articles published in the same journal in the same two years. Only journals that are part of a dedicated database are used in the JIF computations. In general, the more citations and the fewer articles published, the higher the JIF will be. Currently, the only database used is that from the Thompson Scientific, a private company from the United States that releases the annual JIF listings in its product, Journal Citation Reports (JCR) (Adam, 2002).

The original idea of having such a scoring index started in 1955, with support from the National Institutes of Health, was to help select additional source journals into a bibliographical database including journals that have low number of articles published (Garfield, 2007). Since then, the JIF of scientific journals has become the centerpiece of scientific enterprise globally. The JIF may have been developed primarily as a bibliographical tool but it is often exploited as a yardstick for the quality of research and researchers (Seglen, 1997; Walter et al., 2003). Particularly, the JIF appears to be equally important to both the authors and journal editors, in that the authors strive for it for their career advancement and the better likelihood for obtaining research funding, while the editors bother about it because higher JIF can attract more quality submissions and receive better recognition for the journal. Interestingly, the JIF is the subject of many heated debates in the scholarly world (Adam, 2002; Golubic et al., 2008; Seglen, 1997; Walter et al., 2003; and Williams, 2007). A major criticism is that the computation of JIF is not transparent, and that it is the property of a private company, Thompson Scientific (Adam, 2002; Golubic et al., 2008). There are allegations that journal editors are manipulating the JIF by allowing advantageous numbers to be extrapolated into the JIF equation, some going to the extent of being unethical (Williams, 2007; Hemmingsson et al., 2002; Redman and Merz, 2006; Trikalinos, 2008; Atlas, 2003; and Albert et al., 2005).

Some of the common publication gaming can include reliance on self-citations and publishing more nonresearch articles to increase the associated JIF. Self-citations can be defined as citing previous publications by the same author(s) or journal in a new publication. Particularly, author self-citations exist when the citing and the cited article have at least one author in common. This practice is also common where publications in a journal cite previous publications in the same journal, and it is known as journal self-citations (Gami et al., 2004; Fassoulaki et al., 2000). Present JIF calculation includes both the author or journal self-citations. However, this causes numerous debates about the validity of JIF as a measuring metric and the biasness of including self-citations in the JIF derivation (Hyland, 2003; Nieminen et al., 2006; Smith, 1997). It is also argued that self-citations can misrepresent the importance of individual articles, skew the JIF computation, and overvalue the cited publications (Gami et al., 2004; DeMaria, 2003). The other common publication gaming tactic is to keep the numbers of citable or scholarly articles as low as possible. In doing so, the associated JIF can be maximized due to its derivational computations (Nieminen et al., 2006; DeMaria, 2003). It must be recognized that there are several artefacts that can influence the computed JIF. Review articles or letters to editors are generally cited more than research original articles, so boosting review content can make journals perform better. Moreover, citations to news articles, editorials, and media reviews are included in the numerator of the JIF calculation and without increasing its associated denominator (Garfield, 2006; Ioannidis, 2005; Nakayama et al., 2003; Callaham et al., 2002). It is believed that publication gaming can cause marginal increase in the JIF temporary. Without publishing quality research articles, it would be difficult to sustain the JIF over time (Brown, 2007).

Although there is much being written about the JIF derivation and how it can be affected (Adam, 2002; Garfield, 2006; Golubic et al., 2008; Hobbs, 2007; Seglen, 1997; Walter et al., 2003; Williams, 2007; Hemmingsson et al., 2002; Redman and Merz, 2006; Trikalinos, 2008; Atlas, 2003; and Albert et al., 2005), there is limited progress that systematically reconciles the JIF disparity between different disciplines of scientific journals. Scholarly efforts to address the disparity for authors in different disciplines have recently proposed the ‘‘h index’’ and its extended form (Kinney, 2007; Hirsch, 2007). It is worth noting that the aim of this study is neither to reiterate the use of the JIF nor outline the potential shortcomings of its computation processes. These controversy issues are part of the ongoing debates in the scholarly world (Gami et al., 2004; Fassoulaki et al., 2000; Hyland, 2003; Nieminen et al., 2006; Smith, 1997; DeMaria, 2003; Ioannidis, 2005; Nakayama et al., 2003; Callaham et al., 2002; Brown, 2007), and it is beyond the scope of this study. However, the current assessment of academic research outcomes in engineering-based disciplines becomes asymmetrical when it is being benchmarked with that of the sciences in a multidisciplinary institution. Hence the objectives of this study were to: (1) analyze the bibliographical classification of published items and elements of the JIF equation for the journals from the two disciplines of sciences and two disciplines of engineering, (2) assess a weighted factor in computing the citation index for the journals of different disciplines.

Methods

The analysis included two top-ranked journals from four subject categories of the 2007 JCR, namely, two from the General and Internal Medicine: *New England Journal of Medicine* (*NEJM*) and *Lancet*: two from the Multidisciplinary Sciences: *Science* and *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*); two from the Electrical and Electronic Engineering: *Proceedings of the IEEE* (*PIEE*) and *IEEE Transactions on Pattern Analysis and Machine Intelligence* (*PAMI*); and two from the Biomedical Engineering: *Annual Review of Biomedical Engineering* (*ARBE*) and *Biomaterials*. To facilitate comprehensive appreciation of the JIF, the classification of all the published items in the 2005 and 2006 volumes for all the eight journals was performed. Both the volumes were selected because these two volumes formed the basis for the 2007 JIF as computed by Thomson Scientific. Based on the definition of Thomson Scientific, only research items can be used in the denominator of the JIF calculation. As defined in the Web of Science database of Thomson Scientific, only articles and reviews fall under the research items category.

Statistical calculations were performed using the EXCEL 2007 package (Microsoft Corporation, Seattle, WA). The 2005 and 2006 bibliographical classification of published items and elements of the eight selected journals are as shown in Table 1 and Table 2, respectively. In the two tables, each research item was segregated from the total published items of each journal. The relationship between the 2005 published items and 2006 published items was examined using a single linear regression analysis. The same statistical treatment was applied to test the degree of regression for the research items, total citations

TABLE 1 Number of research and total published items in the selected eight journals in the year 2005. Citations the journals receive for their research and total published items in the year 2007. The number and citations of the research items are also calculated as a percentage of the total published items

	2005					
	Research items				Total items	
Journal	Number	%	Citations	%	Number	Citations
New England Journal of Medicine	315	17.29%	14709	87.46%	1822	16818
Lancet	400	23.54%	9696	89.52%	1699	10831
Science	923	34.79%	22022	91.40%	2653	24094
Proceedings of the National Academy of Sciences of the United States of America	3285	92.04%	32792	98.97%	3569	33134
Proceedings of the IEEE	146	83.43%	533	97.98%	175	544
IEEE Transactions on Pattern Analysis and Machine Intelligence	194	98.98%	428	100.00%	196	428
Annual Review of Biomedical Engineering	11	91.67%	190	100.00%	12	190
Biomaterials	764	99.09%	4688	99.96%	771	4690

received by the journal, and citations accredited to research items for the year 2005 as well as 2006. Moreover, the 2007 citation trend of the eight journals was analyzed from 2004 to 2005.

Results

From Tables 1 and 2, it can be observed that most of the published items (>65%) in the science-based disciplines (*NEJM*, *Lancet*, and *Science*) were nonresearch items as classified in the Web of Science database. These items were editorial material, letters, news items, book reviews, bibliographical items, or corrections. Conversely, fewer nonresearch items (<22%) were observed for the engineering based journals. Interestingly, only the *PNAS* journal seemed to have published more research items (>91%) and yet

TABLE 2 Similar results in the number of items being published in the year 2006 with the citations received in the year 2007

	2006					
	Research items				Total items	
Journal	Number	%	Citations	%	Number	Citations
New England Journal of Medicine	295	16.77%	10482	82.95%	1759	12637
Lancet	335	18.04%	4979	81.93%	1857	6077
Science	898	33.60%	16162	88.97%	2673	18165
Proceedings of the National Academy of Sciences of the United States of America	3276	91.15%	25562	99.15%	3594	25781
Proceedings of the IEEE	116	78.91%	132	100.00%	147	132
IEEE Transactions on Pattern Analysis and Machine Intelligence	169	98.83%	143	100.00%	171	143
Annual Review of Biomedical Engineering	19	100.00%	90	100.00%	19	90
Biomaterials	617	99.20%	2591	99.77%	622	2597

managed to be amongst the top ranked in its 2007 JCR subject category. The results from the single regression analysis confirmed that there is correlation ($R^2 \geq 0.992$) in the number of research and published items, as well as the citations to research and published items for all the eight selected journals during the year 2005 and 2006 as given in Fig. 1 and Fig. 2, respectively.

From the 2007 JCR, it is not immediately clear how the JIF value for each journal is being derived. A comparison to its associated Web of Science database, there seems to be a discrepancy in the "number of articles published in" and "cites in 2007 to articles published in." For example, there are 194 research items (192 articles and 2 reviews) published in the *PAMI* journal in 2005 while receiving a total of 428 citations in the year 2007 for these

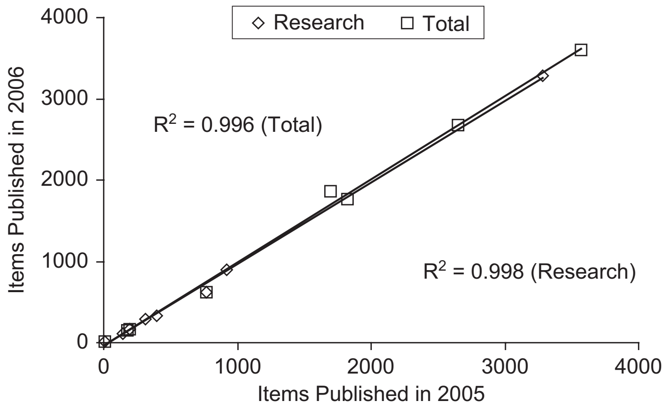

FIGURE 1 The single regression analysis reveals that the number of items published for all the eight selected journals do not vary significantly for the years 2005 and 2006.

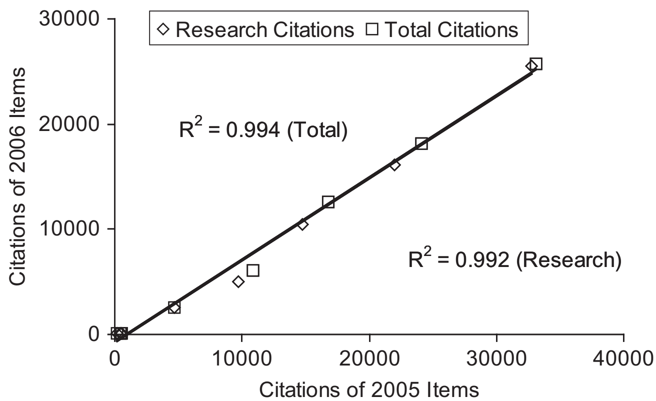

FIGURE 2 A similar result can be seen in the single regression analysis on the number of citations to the items published in 2005 and 2006 during the year 2007.

items. However, according to the 2007 JCR report, the number of items published for the same journal in 2005 is 179, while the citation in 2007 to these items is reported to be 842. Therefore, it appears that the numerator and denominator used in the JIF equation as described in the JCR report are different with the available information from the Web of Science database.

Table 3 shows the reported JIF of the selected eight journals in the 2007 JCR, the various impact factor computations using different citations as numerator and items as denominator, and a weighted factor derivation. The inclusion of nonresearch items tends to have detrimental effect on the JIF computation. The weighted factor rationale is based on the observed trend in the Web of Science database that items published in 2005 receives much higher citations than those published in 2006. In this model, the former value has a weighted factor of 2 when compared to the latter that does not receive any. This is expected as the

TABLE 3 The JIF value for each of the journals as reported in 2007 JCR, and various combinations of available information obtained from the web of science database

	2007				
Journal	Reported JIF	Computed JIF (RC/RI)	Computed JIF (TC/RI)	Computed JIF (TC/TI)	Weighted JIF
New England Journal of Medicine	52.589	41.297	48.287	8.225	23.599
Lancet	28.638	19.966	23.004	4.755	12.920
Science	26.372	20.969	23.206	7.934	22.673
Proceedings of the National Academy of Sciences of the United States of America	9.598	8.894	8.980	8.225	23.631
Proceedings of the IEEE	3.820	2.538	2.580	2.099	4.904
IEEE Transactions on Pattern Analysis and Machine Intelligence	3.579	1.573	1.573	1.556	3.856
Annual Review of Biomedical Engineering	11.567	9.333	9.333	9.032	25.307
Biomaterials	6.262	5.271	5.277	5.231	14.433

Notes: RC: Citations to Research Items; RI: Number of Research Items; TC: Citations to Total Published Items; TI: Number of Total Published Items.

TABLE 4 The citation trend of the eight selected journals over a 3-Year period. It can be seen that there is a general decline for the Science-Based disciplines, while the Engineering-Based journals experience a marginal growth

Journal	2004	2005	2006	2007
New England Journal of Medicine	2226	12499	15207	14773
Lancet	1519	7923	9560	9380
Science	4454	22144	26301	26437
Proceedings of the National Academy of Sciences of the United States of America	4872	26093	30535	29908
Proceedings of the IEEE	40	222	382	473
IEEE Transactions on Pattern Analysis and Machine Intelligence	19	259	598	477
Annual Review of Biomedical Engineering	1	76	178	199
Biomaterials	208	2049	3302	3803

longer the item is published, the higher the likelihood it is read and used as a reference for other research work. Furthermore, the weighted factor acts as a compensation for journals that focus on longer turnover work like those in the engineering disciplines. Using the 2004 JCR data, it can also be seen that the citations received in the third year generally decline for the science-based disciplines, while a relatively lesser increment (when compared to the 2005 JCR data) for the engineering-based disciplines as given in Table 4.

Discussion

From the present study, the JIF computation is still regarded as important and relevant as a form of assessment on the quality of scientific journals. Eight top ranked journals from four different subject categories were evaluated. The results reveal that science-based journals publish significantly more items but not necessarily research items when compared to engineering-based journals. However, the JIF computation seems to also include citations due to these nonresearch items, thereby putting journals that publish few or none nonresearch items at a disadvantage position. Furthermore, it is unclear how the numerator and denominator used in the JIF calculation are being derived in the JCR report. A manual check with the associated Web of Science database from the same company shows discrepancy in the reported values in the number of research items published as well as citations. This is probably the heart of the ongoing heated debates in the scholarly world about JIF (Adam, 2002; Golubic et al., 2008; Seglen, 1997; Walter et al., 2003; Williams, 2007). The discrepancy may be due to errors in reference lists in the citing articles, errors during data entry, or the possibility that the sources for the citations quoted in the JCR are not restricted to the Web of Science database (Golubic et al., 2008). Further investigations are required before comprehensive understanding of the discrepancy can be obtained.

A journal may publish higher number of nonresearch items in order to acquire higher citations that indirectly increase the numerator of the JIF equation. From the analysis, it seems that the increase is marginal. However, it is arguable that intangible impact of the nonresearch items on the associated JIF cannot be undermined as these items may attract significantly more and wider scope of readers. It is also believed that short turnover basic science work is widely referenced for a short time thereby enhancing the citation value in the computed two-year window. Journals that publish weekly are also likely to get more citations than those publish monthly as the likelihood of being more widely read is higher (Hobbs, 2007). With a higher number of published items in a journal, the likelihood of misclassifying item as nonresearch by Thompson Scientific increases due to the diversity in any given discipline. These items may contain results of original research and receive considerable citations, thus increasing the JIF (Brown, 2007). The lack of transparency from Thomson Scientific hinders the verification of this important information (Adam, 2002; Golubic et al., 2008).

There are reports that many large journals have adapted their content and classification to customize to the JIF equation (Golubic et al., 2008). For example, *Lancet* that started its "Research Letters" in 1997 experienced a decline in the JIF and eventually discontinued these items (Joseph, 2003; Chew et al., 2007). Despite the many arguments about JIF, many academic and research communities have incorporated this scoring index firmly into the criteria for career advancement and securing research funding (Seglen, 1997; Walter et al., 2003). The attempt to void the JIF will probably require a lengthy persuasion of many stakeholders and their active involvement in the change process. At the heart of the matter, journals that publish nonresearch items about the misuse of JIF, are still proudly market their JIF and endorsing the need for it (Golubic et al., 2008). Thus, it may still be a long way before anything feasible can be initiated. Until then, more comprehensive approach to derive JIF should be encouraged. In this study, a weighted factor to compute a more balanced JIF is proposed to minimize the over reliance on nonresearch items to increase JIF and the biasness towards short turnover research work.

It is acknowledged that there are limitations to the present study. Firstly, the analysis was only restricted to eight journals in four different subject categories. Due to the complexity in using all the journals listed in the 2007 JCR, journals that are representative in the subject categories were selected. To be comparable, only the top ranked journals in these categories according to JIF were included. Another limitation is the total reliance on the Web of Science database and the 2007 JCR report in formulating all the analysis in this study. This is based on the assumption that the data from these sources are totalling reliable. Thirdly, practical issues such as selective citations and general JIF gaming cannot be readily addressed regardless of how comprehensive a computational model can be.

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