What Makes a Great Journal Great in the Sciences? Which Came First, the Chicken or the Egg?*

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Abstract

The paper is concerned with analysing what makes a great journal great in the sciences, based on quantifiable Research Assessment Measures (RAM). Alternative RAM are discussed, with an emphasis on the Thomson Reuters ISI Web of Science database (hereafter ISI). Various ISI RAM that are calculated annually or updated daily are defined and analysed, including the classic 2-year impact factor (2YIF), 5-year impact factor (5YIF), Immediacy (or zero-year impact factor (0YIF)), Eigenfactor, Article Influence, C3PO (Citation Performance Per Paper Online), h-index, Zinfluence, PI-BETA (Papers Ignored - By Even The Authors), Impact Factor Inflation (IFI), and three new RAM, namely Historical Self-citation Threshold Approval Rating (H-STAR), 2 Year Self-citation Threshold Approval Rating (2Y-STAR), and Cited Article Influence (CAI). The RAM data are analysed for the 6 most highly cited journals in 20 highly-varied and well-known ISI categories in the sciences, where the journals are chosen on the basis of 2YIF. The application to these 20 ISI categories could be used as a template for other ISI categories in the sciences and social sciences, and as a benchmark for newer journals in a range of ISI disciplines. In addition to evaluating the 6 most highly cited journals in each of 20 ISI categories, the paper also highlights the similarities and differences in alternative RAM, finds that several RAM capture similar performance characteristics for the most highly cited scientific journals, determines that PI-BETA is not highly correlated with the other RAM, and hence conveys additional information regarding research performance. In order to provide a meta analysis summary of the RAM, which are predominantly ratios, harmonic mean rankings are presented of the 13 RAM for the 6 most highly cited journals in each of the 20 ISI categories. It is shown that emphasizing THE impact factor, specifically the 2-year impact factor, of a journal to the exclusion of other informative RAM can lead to a distorted evaluation of journal performance and influence on different disciplines, especially in view of inflated journal self citations.

Keywords: Research Assessment Measures (RAM), impact factors, Immediacy, Eigenfactor, Article Influence, Cited Article Influence, h-index, C3PO, Zinfluence, PI-BETA, IFI, H-STAR, 2Y-STAR.

JEL Classifications: C43, C10, Z0.

Be not afraid of greatness:
some are born great, some achieve greatness,
and some have greatness thrust upon them.

Malvolio, Twelfth Night
William Shakespeare (1564-1616)

1. Introduction

Although there is a multitude of contradictory biblical, bibliographical, conceptual, Darwinian, definitional, evolutionary, genetic, grammatical, literary, logical, logistical, mathematical, paleontological, paradoxical, philosophical, processional, and theoretical possibilities associated with the perennial question as to which came first, the chicken or the egg, the same question may also be asked in the context of which came first, the great paper or the great journal in which the paper was published. In short, does the quality, somehow defined, of a journal define the quality of a paper, the reverse, or both?

High quality published research is fundamental to all individual researchers in the sciences and social sciences. In this regard, research assessment rankings are essential to evaluate the research performance of individuals and the quality of academic journals. The perceived research performance of individual researchers can be crucial for hiring, firing, tenure and promotion decisions. In the absence of suitable information regarding the perceived quality of research output, the quality of a journal has frequently been used as a proxy for the research quality of an academic paper. Publishing in a prestigious journal can provide great stimulus to moving in the right direction along the career path. In this context, how might quality and prestige be defined quantitatively?

The perceived quality of a journal would be seen by many as an inappropriate and misleading proxy for the inherently latent quality of a paper, especially in the early years of publication. The quality and prestige of a leading journal is based on the quality of published papers. However, a leading journal cannot be an accurate reflection of the quality of a recently published paper, especially when the paper has received few if any citations to date, and all the more so if a paper is yet to appear in the pages of a journal (for more on this, see Seglen (1997), who finds that citation rates of papers determine the impact factor of journals, and not vice-versa).

It should be borne in mind that the acceptance of a paper for publication in a journal is typically based on one or more of the Editor, Co-editor, Associate Editor, and 1-3 referees. This small group of experts decides the rejection rate prior to publication. It is well known that even experts can and do make mistakes. The rejection rate of a journal after publication depends on the profession. For this reason, it is essential to know the proportion of published papers that is ignored by the profession, and by even the authors. The large market of researchers worldwide is less prone to making errors regarding the quality of academic research papers than a small group of experts at any journal, great or otherwise. This is the reason Chang et al. (2010) proposed PI-BETA (Papers Ignored – By Even The Authors) as a RAM to capture such mistakes after publication.

Type I and Type II errors arise in any decision made under uncertainty, namely bad papers that are accepted for publication in a journal, and good papers that are rejected. As noted in Chang et al. (2010): “Great papers appear in great journals [and] All great journals publish great papers [but] Not all papers in great journals are great.” Papers that have zero citations after a number of years are clearly errors, whether or not they appear in great journals. Editors, Co-editors, Associate Editors and referees may not care about bad papers that are accepted for publication in a journal, but PI-BETA allows the reader to decide whether decisions to publish papers have been prescient.

For purposes of evaluating the research performance of individual researchers and the quality of academic journals, some Research Assessment Measures (RAM) are subscription based, while others can be downloaded free of charge from the Internet. A leading high quality database for generating RAM is the Thomson Reuters ISI Web of Science database (hereafter ISI). This paper examines the importance of ranking RAM, emphasizes the importance of RAM as viable rankings criteria, highlights the usefulness of existing RAM from Thomson Reuters ISI (hereafter ISI RAM), and evaluates the usefulness of three new RAM.

The empirical analysis of RAM presented in this paper concentrates on the 6 most highly cited journals in 20 ISI categories in the sciences. Garfield (1972) developed citation analysis as a tool in evaluating the impact of journals. Although the question posed in the title of the paper refers to greatness, virtually all RAM measures are based on recent citations, that is, within the past two or five years. Citations capture scientific impact, visibility, performance, influence, utility and prestige, which should not be confused with scientific excellence, quality, content, importance, innovation, scientific progress, intellectual property, industrial transfers, and social benefits, among others. There is no substitute for peer review in evaluating the scientific quality of an individual paper, and hence all of the papers published in journals. Greatness of a journal may be hard to define quantitatively, but the question in the title of the paper still needs to be asked.

As citations form the foundations of most bibliometric measures, the application of a meta analysis of several RAM to the journals in these 20 ISI categories could be used as a template for other ISI categories in both the sciences and social sciences, and as a benchmark for newer journals in a range of ISI disciplines. In addition to evaluating the most highly cited journals in these 20 ISI categories, the paper examines the impact of journal self citations on journal performance, compares alternative RAM, and highlights the similarities and differences of alternative RAM. It is shown that emphasizing THE impact factor, specifically the 2-year impact factor, of a journal to the exclusion of other useful and illuminating RAM, can lead to a distorted evaluation of journal performance and influence on the professions, especially in view of inflated journal self citations.

The plan of the remainder of the paper is as follows. Section 2 presents some key bibliometric research. Section 3 discusses alternative RAM, with an emphasis on the Thomson Reuters ISI Web of Science database. Alternative RAM that are calculated annually or updated daily are defined and analysed, including the 2-year impact factor (2YIF), both with and without self citations, 5-year impact factor (5YIF), Immediacy (or zero-year impact factor (0YIF)), Eigenfactor score, Article Influence, C3PO (Citation Performance Per Paper Online), h-index, Zinfluence, PI-BETA (Papers Ignored - By Even The Authors), Self-citation Approval Rating (STAR), both historical and 2-year, Impact Factor Inflation (IFI), and Cited Article Influence (CAI). Section 4 discusses and analyses ISI RAM data for the 6 most highly cited journals in each of 20 ISI categories in the sciences, and presents harmonic mean rankings of the 13 RAM. Section 5 summarizes the outcomes and discusses some future uses of RAM.

2. Some Key Bibliometrics Research

The bibliometric literature on RAM is extensive, but it is worth mentioning some key papers relating to the limitations of the journal impact factor, type I and type II errors in journal decision processes, alternative measures of the h-index, and correlations across different RAM that are based on citations. All but one of these papers have been published in recent years.

Seglen (1997) argues that the impact factor of journals should not be used to evaluate research of individual researchers. In evaluating the relationship between the impact factor of a journal and the citation rate of an article, the author finds that journal impact factors are not statistically representative of the journal articles of an individual. Moreover, there is a difference in article citation rates in that articles in the more cited half of articles in a journal are much more highly cited than those in the less cited half. Seglen (1997) also presents arguments that the computation of a journal impact factor is fundamentally flawed. Interestingly, article citation rates are found to determine the journal impact factor, but not the reverse.

Following this theme, Kermarrec et al. (2007) try to determine what bibliometric indicators actually measure. They evaluate alternative citations sources, bibliometric indicators, misuse and unintended effects of such indicators, and costs of indicators and their implications. The authors conclude that impact and quality are not equivalent, that several bibliometric indicators should be used, that comparisons across disciplines should not be made, that bibliometric indicators should be complemented by other measures, especially peer assessment, for purposes of evaluating research output by individuals and research teams, and that the temptation to rely on automated evaluation based on bibliometric indicators should be resisted.

Neuhaus et al. (2009) also discuss the limitations of the journal impact factor, with an emphasis on chemistry. The critical issue investigated is whether a single measure is appropriate for characterizing journal impact in a multidisciplinary setting. The findings, which extend beyond chemistry, show that the information contained in the citation index is inappropriate for purposes of comparison, and that the length of the citation window and the thematic focus of a journal has a significant effect on the journal impact factor. Overall, the authors find that the journal impact factor is insufficient for characterizing the significance and performance of multidisciplinary journals.

Each of these three papers emphasizes that impact is not equivalent to quality, and that more than one RAM, specifically the journal impact factor, should be considered in evaluating a journal. In short, relying solely on the journal impact factor, regardless of the citation window, is bound to be misleading, so more than one RAM should be used. It is difficult to argue with such a conclusion.

Bornmann and Daniel (2009) consider type I and type II errors in editorial decisions in chemistry, specifically a citation analysis for papers that were accepted by the journal, or rejected by the journal and subsequently published elsewhere. It was found that 15% of the papers had a type I error, namely accepted papers that performed no better than the average rejected paper, and that 15% of the papers were affected by type II error, whereby rejected papers performed at least as well as the average accepted paper. Thus, the authors were able to calculate the extent to which the future success of published papers could be over- or under-estimated on the basis of editorial decisions.

Two papers provide a systematic analysis of the h-index as a bibliometric measure of publication activity and citation impact. Schubert and Glanzel (2007) test a theoretical model of Hirsch-type indexes on the number of publications and the average citation rate. The deterministic model relates the h-index to the cube root of the product of the number of publications and the square of the journal impact factor. The empirical model suggests that the relationship is linear and the weight is approximately 0.75, with a high goodness-of-fit. Thus, the data suggest that the h-index is highly correlated with a nonlinear function of the number of publications and the impact factor, such that the RAM are related.

Bornmann et al. (2008) compare the h-index and eight important variations thereof for purposes of evaluating research output and the journal impact factor. In particular, it is intended to evaluate whether any of the variations of the h-index have an incremental contribute to evaluating research performance. One variation of the h-index describes the most productive core of research output and the papers in that core, whereas the other variation of the h-index describes the impact of the papers in the core. Using a logistic regression, it was found that peer assessments could be predicted more accurately using the impact of the productive core than the quantity of the output in the core.

In the final paper in this section, Elkins et al. (2010) calculate the pairwise correlations between the ISI journal impact factor and three other journal citation indexes, namely the Eigenfactor™ metrics article influence score, SCImago's journal rank index, and the Scopus trend line index. The correlations of the six pairings of four indexes were found to be strong to very strong (lying between 0.61 and 0.89), thereby providing evidence of convergent validity, that is, closely related average journal citations per article. From a purely statistical perspective, it does not seem to matter which index might be used to capture the impact of citations, despite substantial differences in constructing the different citations measures.

3. Research Assessment Measures (RAM)

Several Research Assessment Measures (RAM) are available for recording research performance. Some of these measures are subscription based, while others are downloadable free from the Internet. Alternative sources of RAM are discussed briefly below.

3.1 Thomson Reuters ISI Web of Science

The Thomson Reuters ISI Web of Science database is available to subscribers. Although books and non-ISI journals are not included in the database, a wide range of leading journals is included in the ISI database for an extended period. According to ISI Web of Science (2010): "Authoritative, multidisciplinary content covers over 10,000 of the highest impact journals worldwide, including Open Access journals and over 110,000 conference proceedings." The broad range of RAM may readily be modified to measure research productivity and citations impact of academic researchers and ISI recognised journals.

Alternative excellent databases include the Social Science Research Network (SSRN) database, which includes a very large number of working papers and publications in the social sciences (including economics, finance, accounting, marketing and management, among others), the Research Papers in Economics (RePEc) database for economics (which excludes self citations by both individual researchers and journals in compiling all the RAM statistics), the Scopus subscription-based database, and free Internet databases, such as Google Scholar. Each of these databases has their strengths and limitations (see Kermarrec et al. (2007) for a very useful analysis of the limitations of several citation-based bibliometric indicators). However, ISI would seem to establish the 'gold standard' database for purposes of generating RAM for journals and individual researchers in a wide range of disciplines in the sciences and social sciences for an extended period.

3.2 Definitions of ISI RAM

The existing and new RAM presented below are useful descriptive statistics, and are based on ratios or differences. They are not based on statistical or econometric models, and require no estimation, but rather calculation. Nine RAM, namely 2YIF, 2YIF*, 5YIF, Immediacy, IFI, C3PO, PI-BETA, Article Influence, Cited Article Influence, are based on ratios, two RAM, namely H-STAR and 2Y-STAR, are based on differences, and two RAM, namely h-index and Eigenfactor, are descriptive. In view of the convincing suggestions arising from several papers in Section 2 that more than one RAM, specifically the journal impact factor, should be considered in evaluating a journal, we consider 13 RAM in total and a robust method of combining them.

3.2.1 Annual RAM

With two exceptions, namely the Eigenfactor and Article Influence scores, existing RAM is reported separately for sciences and social sciences, and may be computed annually or updated daily. Annual RAM are calculated for a Journal Citations Reports (JCR) calendar year, which is the year before the annual RAM are released (usually in mid-year). For the JCR year 2008, the annual RAM were released in mid-2009.

The following RAM are defined in Table 1, and are discussed briefly below:

(1) 2-year impact factor (2YIF):

The classic 2-year impact factor (2YIF) of an ISI journal is typically referred to as "THE impact factor", and is calculated annually. The choice of two years as a citation window for measuring journal impact would seem to be arbitrary. As is widely known, impact factors are journal impact factors, and are intended to evaluate journals rather than papers published in journals. The range of 2YIF is from zero upwards. For the JCR year 2008, total citations are for papers published in 2006 and 2007. [It is worth noting that there can be confusion regarding the definition and meaning of impact factors. For example, Bergstrom and West (2008, p. 1850), the developers of Eigenfactor™ metrics, incorrectly state that "Impact factor is essentially a measure of the average number of citations that a journal's articles receive over the two calendar years following publication.]

(2) 2-year impact factor without self citations (2YIF*):

ISI reports a "2-year impact factor without journal self citations", that is, excluding citations to a journal where a citing paper is published. As this impact factor is not widely used, we will refer to this RAM measure as 2YIF*. The range of 2YIF* is from zero upwards.

(3) 5-year impact factor (5YIF):

The 5-year impact factor (5YIF) of an ISI journal is similar to 2YIF, and is calculated annually. The choice of five years as an alternative citation window for measuring journal impact would seem to be arbitrary. The range of 5YIF is from zero upwards. For the JCR year 2008, total citations are for papers published in 2003, 2004, 2005, 2006 and 2007.

(4) Immediacy:

Immediacy is effectively a zero-year impact factor (0YIF) of an ISI journal, and is calculated annually. The choice of the present year as a citation window for measuring journal impact would seem to be arbitrary, and would be more useful for some disciplines than others. The range of Immediacy is from zero upwards. For the JCR year 2008, total citations are for papers published in 2008.

(5) Eigenfactor score:

The Eigenfactor score (Bergstrom (2007), Bergstrom, West and Wiseman (2008)) is a modified 5YIF that is intended to capture "prestige", and is calculated annually. For a JCR year, the Eigenfactor algorithm (see www.eigenfactor.org/methods.htm) ranks journals according to the amount of time researchers are logged on to a journal's website. To state the obvious, the Eigenfactor is unable to check how much time researchers spend reading hard copies of journals. The range of Eigenfactor is from zero upwards.

(6) Article Influence:

Article Influence is a standardized Eigenfactor score, is calculated annually, and measures the relative importance or "influence" of an ISI journal on a per-article basis. The range of Article Influence is from zero upwards.

(7) IFI:

The ratio IFI = 2YIF/2YIF* is intended to capture how journal self citations inflate the impact factor of a journal. The minimum value for IFI is 1, with any value above the minimum capturing the effect of journal self citations on the 2-year impact factor. Thus, the range of IFI is from one upwards.

3.2.2 Two New RAM (computed annually)

ISI has recognized the inflation in journal self citations by calculating an impact factor that excludes such self citations, and provides data on journal self citations, both historically and for the preceding two years, in calculating 2YIF (though not 5YIF or Immediacy). In this paper, we suggest two new RAM, as follows:

(8a) H-STAR:

For the Historical Self-citation Threshold Approval Rating (H-STAR), if HJS = historical journal self-citations (in per cent), the difference between citations in other journals and journal self-citations is H-STAR = (100-HJS) - HJS = 100-2(HJS). Thus, if HJS = 0 (outstanding), 25, 50 or 100 (unthinkable), H-STAR = 100, 50, 0 and -100, respectively. The range of H-STAR is [-100, 100].

(8b) 2Y-STAR:

For the 2 Year Self-citation Threshold Approval Rating (2Y-STAR), if 2YJS = 2 year journal self-citations (in per cent), the difference between citations in other journals and journal self-citations is 2Y-STAR = (100-2YJS) – 2YJS = 100-2(2YJS). Thus, if 2YJS = 0 (outstanding), 25, 50 or 100 (unthinkable), 2Y-STAR = 100, 50, 0 and -100, respectively. The range of 2Y-STAR is [-100, 100].

3.2.3 Daily Updated RAM

Other RAM are updated daily, and are reported for a given day in the current year rather than for a JCR year.

(9) C3PO:

ISI reports the mean number of citations for an ISI journal, namely total citations up to a given day divided by the number of papers published in an ISI journal up to the same day, as the "average" number of citations. In order to distinguish the mean from the median and mode as an "average", Chang et al. (2010) use C3PO (Citation Performance Per Paper Online) of an ISI journal on any given day as the mean. The range of C3PO is from zero upwards. [Note: C3PO should not be confused with C-3PO, the Star Wars android.]

(10) h-index:

The h-index (Hirsch, 2005)) was proposed to assess the scientific research productivity and citations impact of individual researchers. Although the h-index can also be calculated for journals, it should be interpreted as assessing the impact of highly cited publications in ISI journals. The h-index includes journal self-citations. The range of the h-index is from zero upwards.

(11) PI-BETA:

A recently suggested ISI RAM measures the proportion of papers in a journal that has never been cited, which is, in effect, a rejection rate after journal publication. Chang et al. (2010) argue that lack of citations of a published paper, especially over an extended period, may detract from the quality of a journal by exposing: (i) what might be considered as incorrect decisions by the editorial board of a journal; and (ii) the lost opportunities of papers that might have been cited had they not been rejected by the journal. For this reason, Chang et al. (2010) define a paper with Zinfluence as "zero influence, based on zero citations in ISI journals"**,** which can be measured by PI-BETA (= Papers Ignored - By Even The Authors). As PI-BETA is given as a fraction, the range is [0, 1].

3.2.4 A New RAM (updated daily)

(12) Cited Article Influence (CAI):

Article Influence is intended to measure the average influence of an article across the sciences and social sciences. As an article that is not cited cannot have influence, a more plausible measure of the influence of cited articles is Cited Article Influence (CAI). If PI-BETA = 0, CAI would be equivalent to the Article Influence; if PI-BETA = 1, then CAI = 0. As Article Influence is calculated annually, whereas PI-BETA is updated daily, CAI would also be updated daily. The range of Cited Article Influence is from zero upwards.

3.3 Caveats regarding ISI RAM

The inclusion of all articles in an ISI journal includes papers, abstracts and book reviews, and possibly even conference reviews, software reports, and letters to the editor. Although RAM can be very useful and informative, it is worth emphasizing that it is not entirely free of measurement error. The following caveats should be considered in using RAM (for further details see, for example, Garfield (1972) and Kermarrec et al. (2007)).

ISI citations can be affected by misspellings of the titles of journals and names of authors, incorrect use of author's initials, and incorrect year of publication, volume number, and/or the starting page number of the ISI journal article. Only those citations that are correct in every respect will be attributed correctly to the cited author. Otherwise, any error will lead to a different citation, such that the total citations of a publication for a particular author will be too low. Any missing in action (MIA) citations are the responsibility of the citing author(s), and not of ISI. It is virtually impossible to check for spelling variations on the names of any authors as the possibilities are endless.

Further caveats relate to the date of downloading ISI RAM, as daily updates will change the h-index, C3PO, PI-BETA, STAR and CAI scores. The time period for downloading ISI RAM should also be noted as all the ISI RAM will change annually. For journals such as Nature and Science, as well as several journals in the medical sciences, which have a high frequency of publication and publish a large number of articles, the default option for daily ISI RAM updates would seem to vary between two and four years. Otherwise, the threshold of 10,000 articles for purposes of obtaining daily ISI RAM updates will be exceeded. Shortening the period of analysis will necessarily reduce the h-index of a journal, increase C3PO and decrease PI-BETA, but will not bias the analysis against the inherent quality of any journal.

4. Analysis of ISI RAM Data

μεṯαβολή ράνṯων γλυκύ
[*a change is always nice*]

Euripides Orestes, 234

Variety's the very spice of life,
That gives it all its flavour.

William Cowper (1731-1800)

The primary purpose of this section is to evaluate, using 13 RAM, the 6 most highly cited journals in each of 20 highly-varied and well-known ISI categories in the sciences. The journals are chosen on the basis of the most widely-used ISI RAM, namely the 2-year impact factor (2YIF). The 6 most highly cited journals, as well as the total number of journals in each of the 20 ISI categories (in parentheses), are given in Table 2. As there were 8 overlapping journals across the 20 categories, namely Advanced Materials, Annual Review of Earth and Planetary Sciences, Communications on Pure and Applied Mathematics, Global Change Biology, Environmental Health Perspectives, International Journal of Nonlinear Sciences and Numerical Simulation, Mathematical Programming, and Nano Letters, there are 112 distinct journals.

Only articles from ISI Web of Science are included in the citation data. Data for all journals were downloaded from ISI on 4 June 2010 for all citations for 1988-2010, so that citations are counted from 1988 for all papers published in an ISI journal since 1988. As ISI does not provide daily updates for more than 10,000 articles for purposes of calculating the h-index, C3PO, PI-BETA and CAI, the initial years of several journals were chosen so that no journal had more than 10,000 articles.

Of the 112 distinct journals, 21 had the period of analysis truncated from 1988-2010 in order to be able to provide the daily updated ISI RAM. These 22 journals are as follows (with starting year given in parentheses): Astrophysical Journal (2007), FASEB Journal (2007), Angewandte Chemie - International Edition (2005), Environmental Health Perspectives

(1989), New England Journal of Medicine (2005), JAMA - Journal of the American Medical Association (2004), Lancet (2005), Annals of Internal Medicine (1994), British Medical Journal (2008), Nature (2007), Science (2007), Proceedings of the National Academy of Sciences of the United States of America (2009), Physical Review Letters (2008), American Journal of Psychiatry (1995), Biological Psychiatry (2001), American Journal of Epidemiology (2000), Epidemiology (1997), American Journal of Transplantation (2005), British Journal of Surgery (1996), Journal of Neurology, Neurosurgery and Psychiatry (1994), and Journal of Comparative Neurology (1989).

As of JCR 2008, the numbers of journals in these 20 categories range from 42 journals in Multidisciplinary Sciences (a category that includes Nature, Science, and Proceedings of the National Academy of Sciences of the United States of America) to 221 journals in Neurosciences. The 13 RAM for the 6 most highly cited journals in each of the 20 ISI categories in the sciences are given in Table 2. The number of articles in the 112 distinct journals has a substantial range, from hundreds up to almost 10,000 articles for the period 1988-2010. As each of the 13 RAM can vary substantially by journal and category, each of the 20 ISI categories will be summarized as High, Medium or Low according for the following RAM:

Group 1: 2YIF, 2YIF*, 5YIF, Immediacy, h-index and C3PO;
Group 2: IFI, H-STAR, 2y-STAR;
Group 3: PI-BETA;
Group 4: Eigenfactor, Article Influence, Cited Article Influence (CAI).

For Group 1, namely performances according to 2YIF, 2YIF*, 5YIF, Immediacy, h-index and C3PO, Mathematics, Operations Research & Management, Statistics & Probability, and Zoology are Low; Astronomy and Astrophysics, Chemistry - Multidisciplinary, Materials Sciences - Multidisciplinary, Medicine - General & Internal, Multidisciplinary Sciences, Neurosciences, and Physics - Multidisciplinary are High; and the remaining 9 ISI categories are Medium.

In Group 2, namely IFI, H-STAR, 2Y-STAR, Astronomy and Astrophysics, Engineering - Multidisciplinary, Geosciences - Multidisciplinary, and Operations Research & Management are High; Chemistry - Multidisciplinary, Ecology, Statistics & Probability, Surgery, and

Zoology are Medium; and the remaining 11 ISI categories are Low. Journal self citation in some categories can be quite high, such as inflated 2YIF by a factor of 1.459 in Astronomy and Astrophysics, 1.290 in Ecology, 4.246 in Engineering - Multidisciplinary, 2.362 in Geosciences - Multidisciplinary, and 1.338 in Operations Research & Management. H-STAR and 2Y-STAR can be as low as 46 and 38 in Astronomy and Astrophysics, 68 an 56 in Ecology, -38 and -52 in Engineering - Multidisciplinary, 14 and -14 in Geosciences - Multidisciplinary, 52 and 50 in Operations Research & Management, and 44 and 68 in Statistics & Probability.

PI-BETA in Group 3 vary markedly, both within and across ISI categories. Only Zoology has a Low PI-BETA, with only one journal having 12.50% of papers that have never been cited. Astronomy and Astrophysics, and Chemistry - Multidisciplinary are Medium, with 13.04% and 18.12% of papers in one journal in each category never having been cited. For the remaining 17 categories in the High classification, the highest percentages of any journal with papers that have never been cited are: 83.77% in Biology, 44.21% in Ecology, 33.55% in Engineering - Multidisciplinary, 69.27% in Environmental Sciences, 30.12% in Geosciences - Multidisciplinary, 97.31% in Materials Sciences - Multidisciplinary, 76.78% in Mathematics, 41.70% in Mathematics - Applied, 72.82% in Medicine - General & Internal, 68.48% in Multidisciplinary Sciences, 57.79% in Neurosciences, 39.60% in Operations Research & Management, 38.98% in Physics - Multidisciplinary, 67.35% in Psychiatry, 78.31% in Public, Environmental & Occupational Health, 46.34% in Statistics & Probability, and 75.61% in Surgery. It should be emphasized that these are not atypical as in 3 (3) categories, 6 of 6 (5 of 6) highly cited journals have extremely high PI-BETA.

In Group 4, namely Eigenfactor score, Article Influence, Cited Article Influence (CAI), there are 4 ISI categories that are High, specifically Astronomy and Astrophysics, Medicine - General & Internal, Neurosciences, and Operations Research & Management. The 6 categories in the Medium range are Biology, Chemistry - Multidisciplinary, Ecology, Geosciences - Multidisciplinary, Materials Sciences - Multidisciplinary, and Physics - Multidisciplinary. The remaining 10 categories are in the Low category. Given the great variations in PI-BETA, the rankings according to Article Influence and CAI can vary substantially.

The correlations between pairs of alternative ISI RAM have long been a source of discussion and debate in the scientific community. Fersht (2009) showed that there was a very strong positive correlation between Eigenfactor and the total number of journal citations. Such strong correlations are not entirely surprising, and would seem to capture the size effect of journals, with the total number of publications and total citations typically being positively and highly correlated.

The simple correlations for the 13 RAM for the 112 highly cited distinct journals in 20 ISI categories in the sciences are given in Table 3. The 6 pairs of RAM for which the correlations exceed 0.9 are (2YIF, 2YIF*), (2YIF, 5YIF), (2YIF*, 5YIF), (5YIF, Article Influence), (Article Influence, CAI), and (H-STAR, 2Y-STAR). Six other pairs of RAM for which the simple correlations lie just below 0.9 (in absolute value) are (2YIF, Immediacy), (2YIF, Article Influence), (2YIF*, Immediacy), (2YIF*, Article Influence), (IFI, H-STAR), and (IFI, 2Y-STAR). PI-BETA is the only RAM that has very low simple correlations with each of the other 12 RAM scores, so that PI-BETA conveys additional information to what is contained in the 12 other RAM scores.

As the aggregation of the RAM across the 20 ISI categories might be masking some differences across the categories, the simple correlations (which are not reported here due to space limitations) have been calculated separately for each of the 20 ISI categories. Bearing in mind that there are only 6 journals in each category for purposes of calculating the correlations, similar comments as in Table 2 generally apply to each of the 20 separate categories, although the simple correlations vary according to RAM and ISI category. The high correlations are least frequent for Environmental Sciences, Materials Sciences - Multidisciplinary, and Mathematics.

It remains to be seen whether an emphasis on THE impact factor, specifically the 2-year impact factor, of a journal to the exclusion of other informative RAM, can lead to a distorted evaluation of journal performance and influence on the profession. In order to provide a meta analysis summary of the RAM, which are predominantly ratios, the overall rankings of the leading 6 journals in each of the 20 ISI categories across the 13 RAM are calculated using the harmonic mean. The harmonic mean rankings are reported in the final column in Table 2.

Of the 20 ISI categories, only 2 categories had no changes in rank orders, namely Biology and Statistics & Probability. Regarding the highest ranked journal in each category according to 2YIF, 14 of the 20 categories had unchanged highest rankings according to the harmonic mean, with only Astronomy and Astrophysics, Ecology, Geosciences - Multidisciplinary, Mathematics - Applied, Operations Research & Management, and Zoology, having their respective most highly cited journals changing in rank order. As Article Influence is a modification of 5YIF, it is interesting to note that 16 of 20 categories had the same journal ranked number 1 according to both RAM, with Ecology, Environmental Sciences, Mathematics, and Statistics & Probability being the only exceptions to the expected outcome. Interesting movements include Operations Research & Management, which had 5 changes in rank order, including one journal falling by 5 places; Surgery had 5 changes in ranks, including 3 journals each changing their ranks by 3 positions; and Engineering - Multidisciplinary had one journal falling by 4 positions.

These empirical findings can be connected to the key bibliometric references in Section 2. They support the view of Seglen (1997) and Neuhaus et al. (2009), among many others, that the impact factor (specifically, 2YIF, though similar comments would also apply to 5YIF, and possibly also 2YIF*), should not be used uncritically. We would temper such a recommendation that impact factors should not be used uncritically, as they do provide descriptive statistics that can be informative. As one such measure of 13 RAM that are used to provide a harmonic mean, impact factors should certainly not be discarded. The empirical results are also consistent with the discussion in Kermarrec et al. (2007), who suggest that several bibliometric indicators should be used. We would concur, such that this paper has used 13 such bibliometric indicators.

PI-BETA supports the consideration of Bornmann and Daniel (2009) by explicitly recognising the existence of errors in editorial decisions by reporting those papers that have zero citations. Schubert and Glanzel (2007) suggested that the h-index is highly correlated with the impact factor, and Bornmann et al. (2008) compared nine important variations of the h-index to evaluate research output and the journal impact factor. In Table 3, the h-index is shown to have correlations in excess of 0.5 with six other RAM (including 0.541 and 0.591 with 2YIF and 5YIF, respectively), which shows there is indeed overlap among the different RAM, especially citation rates. Elkins et al. (2010) found a strong correlation between the journal impact factor (specifically, 2YIF) and the Eigenfactor™ metrics article influence score. Table 3 shows that Article Influence indeed has a high correlation of 0.888 with 2YIF, and an even higher correlation of 0.936 with 5YIF. Overall, the empirical findings of this paper are entirely consistent with the key bibliometric references cited above.

5. Conclusion

The paper discussed alternative Research Assessment Measures (RAM), with an emphasis on the Thomson Reuters ISI Web of Science (hereafter ISI) database. Alternative RAM that are calculated annually or updated daily were defined and analysed, including the classic 2-year impact factor (2YIF), with and without journal self citations, 5-year impact factor (5YIF), Immediacy (or zero-year impact factor (0YIF)), Eigenfactor, Article Influence, h-index, C3PO, Zinfluence, PI-BETA, Impact Factor Inflation (IFI), and three new RAM, namely Historical Self-citation Threshold Approval Rating (H-STAR), 2 Year Self-citation Threshold Approval Rating (2Y-STAR), and Cited Article Influence (CAI).

The RAM data were analysed for the 6 most highly cited journals in each of 20 highly-varied and well-known ISI categories in the sciences. As citations form the foundations of most bibliometric measures, the application of a meta analysis of RAM to the journals in these 20 ISI categories could be used as a template for other ISI categories in both the sciences and social sciences, and as a benchmark for newer journals in a range of ISI disciplines.

In addition to evaluating high quality research in the 6 most highly cited journals in each of 20 ISI categories, with 112 Distinct journals, the paper also compared alternative RAM, highlighted the similarities and differences in alternative RAM, found that several RAM captured similar performance characteristics for the most highly cited journals, determined that PI-BETA was not highly correlated with the other RAM, and hence conveyed additional information. Harmonic mean rankings of the 13 RAM for the 6 most highly cited journals in the 20 ISI categories were also presented. It was shown that emphasizing THE impact factor, specifically the 2-year impact factor, of a journal to the exclusion of other useful and illuminating RAM, could lead to a distorted evaluation of journal performance and influence on the profession, especially in view of inflated journal self citations.

What is the road map for existing and future RAM, most of which are based on citations? Likely future uses of RAM include using RAM for research assessment exercises, and as input into academic appointments and promotions. Conundrums such as whether or not it is better to publish in a journal with: (i) high rather than low two-year impact factor (with and without self citations); (ii) high rather than low five-year impact factor; (iii) high rather than low Immediacy; (iv) high rather than low h-index; (v) high rather than low C3PO; (vi) low rather than high PI-BETA; (vii) high rather than low Eigenfactor score; (viii) high rather than low Article Influence; (ix) high rather than low STAR (both historical and 2-year); (x) low rather than high IFI; and (xi) high rather than low CAI; can also be analysed critically, as such choices will likely increase the probability of being highly cited.

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Table 1

Definitions of Research Assessment Measures (RAM)

RAM	**Definition**
2YIF	Total citations in a year to papers published in a journal in the previous 2 years / Total papers published in a journal in the previous 2 years
2YIF*	2YIF without journal self citations
5YIF	Total citations in a year to papers published in a journal in the previous 5 years / Total papers published in a journal in the previous 5 years
IFI (Impact Factor Inflation)	2YIF / 2YIF*
h-index	Each of h papers is cited at least h times
C3PO (Citation Performance Per Paper Online)	Total citations to a journal / Total papers published in a journal
PI-BETA (Papers Ignored - By Even The Authors)	Number of papers in a journal with zero citations / Total papers published in a journal
Eigenfactor	Modified 5YIF that ranks journals according to the amount of time researchers are logged on to a journal's website
Immediacy (or 0YIF)	Total citations in a year to papers published in a journal in the same year / Total papers published in a journal in the same year
Article Influence	Eigenfactor score / Fraction of all ISI articles published by a journal
Cited Article Influence	(1 - PI-BETA)(Article Influence)
H-STAR (Historical - Self-citation Threshold Approval Rating)	H-STAR = 100 - 2(HJS), where HJS = historical journal self-citations
2Y-STAR (2Year- Self-citation Threshold Approval Rating)	2Y-STAR = 100 - 2(2YJS), where 2YJS = journal self-citations in the previous 2 years

Table 2

Research Assessment Measures (RAM) for 6 Journals in Each of 20 ISI Categories

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean
Astronomy and Astrophysics (48)														
Annual Review of Astronomy and Astrophysics	25.828	25.609	24.370	1.009	138	166.76	0.0653	0.02337	0.692	14.444	13.500	100	100	3
Astrophysical Journal Supplement Series	13.990	13.366	12.119	1.047	175	55.59	0.0475	0.11166	2.638	6.836	6.511	92	92	2
Astronomy and Astrophysics Review	7.500	7.300	8.833	1.027	45	58.39	0.0667	0.00190	1.750	4.758	4.441	96	96	1
Journal of Cosmology and Astroparticle Physics	6.389	4.690	6.026	1.362	53	12.36	0.1251	0.04452	1.847	2.267	1.983	52	48	4
Annual Review of Earth and Planetary Sciences	6.364	6.295	9.040	1.011	80	54.19	0.0713	0.01443	1.368	6.447	5.988	100	98	6
Astrophysical Journal	6.331	4.338	5.743	1.459	72	8.90	0.1812	0.54472	2.083	1.874	1.534	46	38	5
Biology (72)														
Plos Biology	12.683	12.500	14.662	1.015	103	30.13	0.1172	0.15465	2.184	8.744	7.719	98	98	1
Biological Reviews	8.755	8.660	9.343	1.011	63	42.22	0.1013	0.01203	0.379	4.050	3.640	100	98	2
FASEB Journal	7.049	6.943	7.128	1.015	33	1.31	0.8377	0.12998	1.388	2.614	0.424	100	98	3
Quarterly Review of Biology	6.688	6.688	9.023	1.000	63	43.97	0.4378	0.00381	0.143	3.994	2.245	100	100	4
Philosophical Transactions of the Royal Society B-Biological Sciences	5.556	5.414	6.293	1.026	74	17.49	0.0768	0.05692	2.800	2.993	2.763	92	96	5
Bioessays	5.316	5.203	5.509	1.022	143	35.85	0.1136	0.04010	0.813	2.603	2.307	98	96	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean
Chemistry, Multidisciplinary (127)														
Chemical Reviews	23.592	23.360	28.577	1.010	377	193.76	0.0387	0.20288	3.635	11.136	10.705	100	100	1
Chemical Society Reviews	17.419	17.260	17.730	1.009	149	53.35	0.1288	0.05403	3.668	6.382	5.560	100	100	3
Accounts of Chemical Research	12.176	12.104	15.403	1.006	224	96.26	0.0371	0.07275	2.683	5.925	5.705	100	100	2
Angewandte Chemie - International Edition	10.879	9.249	11.025	1.176	133	20.06	0.1304	0.51386	2.657	3.338	2.903	80	72	5
Nano Letters	10.371	9.491	12.189	1.093	162	34.17	0.0869	0.25290	1.524	4.492	4.102	88	84	4
Advanced Materials	8.191	7.631	10.231	2.752	207	40.62	0.0988	0.21353	0.957	3.547	3.196	92	88	6
Ecology (124)														
Bulletin of the American Museum of Natural History	16.692	16.462	4.740	1.014	18	7.38	0.4421	0.00287	1.444	1.772	0.989	94	98	3
Trends in Ecology & Evolution	11.904	11.557	17.188	1.030	182	41.06	0.1397	0.06469	1.913	7.846	6.750	98	96	2
Annual Review of Ecology Evolution and Systematics	10.161	10.000	17.176	1.016	53	51.16	0.0619	0.02416	0.133	8.322	7.807	100	98	1
Ecology Letters	9.392	8.831	9.342	1.064	89	30.81	0.0885	0.06570	1.291	4.431	4.039	92	90	5
Global Change Biology	5.876	5.216	6.709	1.127	92	25.39	0.0765	0.05630	0.866	2.864	2.645	80	78	6
Molecular Ecology	5.325	4.129	5.966	1.290	115	27.75	0.0680	0.06926	1.506	1.811	1.688	68	56	4

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean
Engineering, Multidisciplinary (67)														
International Journal of Nonlinear Sciences and Numerical Simulation	8.479	7.859	5.916	1.079	38	8.32	0.3355	0.01187	0.382	1.739	1.155	86	86	1
CMES - Computer Modeling in Engineering & Sciences	4.785	1.127	3.656	4.246	32	7.96	0.1820	0.00406	1.306	0.474	0.388	-38	-52	6
Nanotechnology	3.446	3.061	3.727	1.126	74	8.87	0.2082	0.09885	0.507	1.233	0.976	82	78	2
International Journal for Numerical Methods in Engineering	2.229	1.831	2.303	1.217	88	14.15	0.1261	0.03278	0.399	0.998	0.872	76	66	5
Archives of Computational Methods in Engineering	2.227	2.227	2.100	1.000	16	8.84	0.2500	0.00070	0.385	0.790	0.593	98	100	3
Combustion and Flame	2.160	1.630	2.657	1.325	78	16.35	0.1045	0.01536	0.436	0.856	0.767	82	52	4
Environmental Sciences (163)														
Critical Reviews in Environmental Science and Technology	7.409	7.364	6.097	1.006	43	27.60	0.1455	0.00257	0.273	1.871	1.599	100	100	1
Environmental Health Perspectives	6.123	5.576	7.069	1.098	140	18.57	0.3106	0.06530	0.897	2.000	1.379	88	84	2
Global Change Biology	5.876	5.216	6.709	1.127	92	25.39	0.0765	0.05630	0.866	2.864	2.645	80	78	4
Frontiers in Ecology and the Environment	5.065	4.676	5.926	1.083	43	4.42	0.6927	0.01551	1.286	2.733	0.840	90	86	6
Conservation Biology	4.705	4.243	5.393	1.109	123	27.26	0.1240	0.03918	0.500	2.073	1.816	92	82	5
Annual Reviews of Environment and Resources	4.667	4.467	6.726	1.045	24	16.81	0.2034	0.00556	0.050	3.438	2.739	96	92	3

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean
Geosciences, Multidisciplinary (144)														
Earth-Science Reviews	6.558	6.442	6.814	1.018	74	31.56	0.1142	0.01475	0.689	3.096	2.743	98	98	2
Annual Review of Earth and Planetary Sciences	6.364	6.295	9.040	1.011	80	54.19	0.0713	0.01443	1.368	6.447	5.988	100	98	1
Global Biogeochemical Cycles	4.090	3.638	4.993	1.124	99	32.22	0.0596	0.03088	0.739	2.538	2.387	84	78	3
Precambrian Research	3.736	2.534	3.912	1.474	78	20.68	0.0945	0.01460	1.401	1.257	1.138	42	36	4
Gondwana Research	3.728	2.156	2.691	1.729	31	6.06	0.2124	0.00569	2.126	0.742	0.584	22	16	5
Geotextiles and Geomembranes	3.701	1.567	3.063	2.362	23	5.37	0.3012	0.00174	0.600	0.553	0.386	14	-14	6
Materials Sciences, Multidisciplinary (192)														
Nature Materials	23.132	22.721	25.759	1.018	142	37.45	0.3415	0.18554	5.326	12.608	8.303	98	98	1
Nature Nanotechnology	20.571	19.756	20.588	1.041	62	17.44	0.2773	0.02936	5.097	11.131	8.045	90	94	4
Progress in Materials Science	18.132	18.000	17.263	1.007	66	80.34	0.1102	0.01283	1.929	7.235	6.437	100	100	2
Materials Science & Engineering R-Reports	12.619	12.524	20.328	1.008	82	101.92	0.9731	0.01107	1.062	8.192	0.220	100	100	3
Nano Letters	10.371	9.491	12.189	1.093	162	34.17	0.0869	0.25290	1.524	4.492	4.102	88	84	5
Advanced Materials	8.191	7.631	10.231	1.073	207	40.62	0.0988	0.21353	0.957	3.547	3.196	92	88	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean
Mathematics (215)														
Communications on Pure and Applied Mathematics	3.806	3.677	3.855	1.035	71	27.12	0.1159	0.02065	0.774	3.757	3.322	98	94	1
Bulletin of the American Mathematical Society	3.500	3.400	3.658	1.029	44	17.30	0.1395	0.00539	0.211	3.334	2.869	100	96	6
Annals of Mathematics	3.447	3.372	3.575	1.022	71	24.23	0.0634	0.02645	1.024	4.487	4.203	98	96	2
Journal of American Mathematical Society	2.476	2.397	3.308	1.033	44	19.35	0.0782	0.01613	0.256	4.666	4.301	98	94	5
Memoirs of the American Mathematical Society	2.367	2.367	2.109	1.000	10	1.01	0.7678	0.00742	0.571	2.594	0.602	100	100	4
Inventiones Mathematicae	2.287	2.250	2.375	1.016	74	19.41	0.0566	0.02498	0.420	3.354	3.164	98	98	3
Mathematics, Applied (175)														
International Journal of Nonlinear Sciences and Numerical Simulation	8.479	7.859	5.916	1.079	38	8.32	0.3355	0.01187	0.382	1.739	1.155	86	86	3
Communications on Pure and Applied Mathematics	3.806	3.677	3.855	1.035	71	27.12	0.1159	0.02065	0.774	3.757	3.322	98	94	1
SIAM Review	2.739	2.717	8.235	1.008	73	24.02	0.4170	0.01179	0.773	4.624	2.696	100	100	2
Applied and Computational Harmonic Analysis	2.344	2.042	2.635	1.148	40	13.52	0.1771	0.00740	0.262	1.845	1.518	82	76	5
Mathematical Programming	2.336	2.147	2.745	1.088	68	16.58	0.1165	0.01722	0.589	1.886	1.666	90	86	4
Mathematical Models & Methods in Applied Sciences	2.333	2.007	1.872	1.162	33	6.91	0.1966	0.00868	0.630	1.041	0.836	82	72	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean ranking
Medicine, General & Internal (107)														
New England Journal of Medicine	50.017	49.212	49.911	1.016	227	22.38	0.4712	0.68029	12.225	18.763	9.921	100	98	1
JAMA - Journal of the American Medical Association	31.718	31.022	27.957	1.022	175	15.56	0.5322	0.38098	7.556	11.148	5.215	98	96	2
Lancet	28.409	27.294	27.264	1.041	156	12.83	0.4921	0.41177	8.505	9.946	5.051	98	94	4
Annals of Internal Medicine	17.457	16.798	16.117	1.039	214	29.00	0.3861	0.12604	4.574	6.270	3.849	98	94	3
British Medical Journal	12.857	12.175	10.665	1.056	31	1.11	0.7282	0.15945	6.032	3.789	1.030	96	90	6
PLOS Medicine	12.185	11.904	13.180	1.024	58	12.42	0.2069	0.05742	3.684	6.139	4.869	94	96	5
Multidisciplinary Sciences (42)														
Nature	31.434	30.865	31.210	1.018	149	15.18	0.4679	1.76345	8.194	17.279	9.194	100	98	1
Science	28.103	27.551	30.268	1.020	132	13.74	0.4226	1.58309	6.261	16.286	9.404	100	98	2
Proceedings of the National Academy of Sciences of the Unites States of America (PNAS)	9.380	9.025	10.228	1.039	31	3.23	0.3689	1.69817	1.635	4.847	3.059	96	94	5
Nano Today	8.795	8.769	9.231	1.003	23	4.61	0.6848	0.00283	1.077	3.278	1.033	100	100	3
IBM Journal of Research and Development	3.722	3.577	3.385	1.041	62	16.86	0.1706	0.00836	1.118	1.440	1.194	94	94	4
Journal of the Royal Society Interface	3.621	3.249	3.908	1.114	27	6.63	0.1880	0.00787	1.117	1.486	1.207	80	80	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean ranking
Neurosciences (221)														
Annual Review of Neuroscience	26.405	26.190	31.209	1.008	183	235.21	0.0020	0.04611	3.348	18.915	18.876	100	100	1
Nature Reviews Neuroscience	25.940	25.497	27.678	1.017	169	42.11	0.5779	0.11399	4.859	13.939	5.883	98	98	3
Neuron	14.170	13.370	14.857	1.060	325	96.62	0.0700	0.28702	2.599	8.296	7.715	92	90	2
Nature Neuroscience	14.164	13.841	16.825	1.023	201	56.18	0.1541	0.19666	3.297	9.120	7.714	98	96	5
Behavioural and Brain Sciences	12.818	11.318	19.355	1.133	109	5.22	0.5657	0.01173	2.667	8.533	3.706	92	78	6
Trends in Neurosciences	12.817	12.640	14.475	1.014	234	80.18	0.1048	0.06325	1.925	6.910	6.186	100	98	4
Operations Research & Management (64)														
Expert Systems with Applications	2.596	1.940	2.638	1.338	39	3.93	0.3960	0.00588	0.524	0.354	0.214	52	50	6
Journal of Operations Management	2.420	2.023	3.814	1.196	46	16.82	0.0934	0.00494	0.364	0.966	0.876	72	68	4
Management Science	2.354	2.080	4.065	1.132	118	28.62	0.1032	0.03318	0.389	2.317	2.078	94	78	1
Mathematical Programming	2.336	2.147	2.745	1.088	68	16.58	0.1165	0.01722	0.589	1.886	1.666	90	84	2
Omega-International Journal of Management Science	2.175	1.939	2.367	1.122	45	9.42	0.1733	0.00389	0.736	0.700	0.579	88	80	5
Systems & Control Letters	2.073	1.955	2.620	1.060	73	13.62	0.1724	0.01377	0.235	1.147	0.949	90	90	3

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean ranking
Physics, Multidisciplinary (68)														
Reviews of Modern Physics	33.985	33.785	40.395	1.006	205	201.07	0.0488	0.08932	7.028	24.877	23.664	100	100	1
Physics Reports - Review Section of Physics Letters	18.522	18.357	16.368	1.009	183	69.75	0.1128	0.05770	3.959	8.060	7.151	98	100	3
Nature Physics	16.821	16.442	17.189	1.023	65	14.98	0.3898	0.07468	4.793	12.715	7.759	94	96	4
Reports on Progress in Physics	12.090	12.034	12.450	1.005	129	74.12	0.0610	0.03287	2.735	6.651	6.245	100	100	2
Physical Review Letters	7.180	6.387	7.134	1.124	61	6.78	0.2096	1.28160	1.974	3.298	2.607	86	78	5
Soft Matter	4.586	4.136	4.890	1.109	37	5.84	0.3062	0.01441	0.834	1.994	1.383	82	82	6
Psychiatry (101)														
Archives of General Psychiatry	14.273	13.795	17.272	1.035	253	81.53	0.1285	0.08916	2.197	6.705	5.844	98	94	1
Molecular Psychiatry	12.537	11.932	11.937	1.051	102	25.48	0.2115	0.04612	4.161	4.247	3.349	92	92	3
American Journal of Psychiatry	10.545	10.202	10.806	1.034	189	26.14	0.3815	0.10924	3.113	3.657	2.262	98	94	2
Biological Psychiatry	8.672	8.305	9.015	1.044	114	9.25	0.6735	0.11389	1.943	3.186	1.040	94	92	4
Neuropsychopharmacology	6.835	6.444	6.716	1.061	116	16.51	0.4399	0.05970	2.106	2.164	1.212	92	90	5
Schizophrenia Bulletin	6.592	5.959	6.333	1.106	116	11.76	0.6422	0.01794	1.372	2.107	0.754	88	82	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean ranking
Public, Environmental & Occupational Health (105)														
Epidemiologic Reviews	12.130	12.130	10.039	1.000	79	56.04	0.0271	0.00454	0.200	4.020	3.911	82	100	1
Environmental Health Perspectives	6.123	5.576	7.069	1.098	140	18.57	0.3106	0.06530	0.897	2.000	1.379	88	84	4
Annual Review of Public Health	6.045	5.864	7.491	1.031	74	40.94	0.0436	0.00780	1.680	3.088	2.953	98	94	2
International Journal of Epidemiology	5.838	5.548	5.845	1.052	101	18.42	0.1378	0.03685	2.060	2.527	2.179	94	92	3
American Journal of Epidemiology	5.454	5.157	6.404	1.058	102	7.72	0.6544	0.07700	1.258	2.587	0.894	94	90	5
Epidemiology	5.406	4.872	5.705	1.110	77	3.73	0.7831	0.02219	1.645	2.139	1.675	90	82	6
Statistics & Probability (92)														
Econometrica	3.865	3.606	4.943	1.072	123	49.81	0.0766	0.04527	0.255	7.243	6.688	98	98	1
Biostatistics	3.394	3.232	5.253	1.050	26	14.57	0.2062	0.01528	0.643	3.011	2.390	96	92	2
Journal of the Royal Statistical Society Series B-Statistical Methodology	2.835	2.729	3.943	1.039	52	22.46	0.1364	0.01756	0.551	3.476	3.002	100	94	3
Annals of Applied Statistics	2.448	2.034	2.483	1.204	9	2.57	0.4634	0.00104	0.403	1.615	0.867	44	68	4
Journal of the American Statistical Association	2.394	2.187	3.462	1.095	126	27.49	0.1740	0.03673	0.187	3.013	2.489	94	84	5
Annals of Statistics	2.307	1.965	3.094	1.174	93	21.29	0.1274	0.03110	0.614	2.998	2.616	90	72	6

Journal	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR	Harmonic Mean ranking
Surgery (148)														
Annals of Surgery	8.460	7.902	9.776	1.071	186	36.58	0.2401	0.06729	1.064	2.699	2.051	94	88	1
American Journal of Transplantation	6.559	5.771	6.281	1.137	56	2.82	0.7561	0.06431	1.213	1.868	0.456	80	76	5
Endoscopy	6.091	5.011	5.268	1.216	78	10.76	0.2563	0.02344	1.451	1.265	0.941	80	66	4
British Journal of Surgery	4.921	4.603	5.108	1.069	100	8.93	0.5670	0.03337	0.806	1.423	0.616	96	88	6
Journal of Neurology, Neurosurgery and Psychiatry	4.622	4.477	4.248	1.032	107	12.45	0.3564	0.04595	1.070	1.323	0.851	96	94	2
Archives of Surgery	4.259	4.089	4.556	1.042	120	18.23	0.3254	0.02484	0.673	1.317	0.888	98	92	3
Zoology (125)														
Wildlife Monographs	4.250	4.000	4.444	1.063	21	25.82	0.1250	0.00073	0.000	1.837	#REF!	94	90	3
Journal of Animal Ecology	4.220	3.918	4.792	1.077	104	32.16	0.0654	0.02795	0.729	2.095	1.958	92	86	1
Journal of Comparative Neurology	3.743	3.262	3.944	1.147	185	36.34	0.0394	0.06616	0.971	1.489	1.430	82	76	2
Journal of Experimental Zoology Part B-Molecular and Developmental Evolution	3.364	3.178	3.227	1.059	28	8.30	0.1696	0.00674	0.633	1.328	1.103	88	90	4
Behavioural Ecology	3.224	2.844	3.726	1.134	71	20.34	0.0819	0.02100	0.495	1.366	1.254	82	78	6
Behavioural Ecology and Sociobiology	2.917	2.561	3.173	1.139	89	24.65	0.0598	0.02141	0.652	1.178	1.108	84	76	5

Note: Citations data were downloaded from ISI on 4 June 2010 for 1988-2010.

Table 3

Correlations for 13 RAM for 112 Distinct Journals in 20 ISI Categories

RAM	2YIF	2YIF*	5YIF	IFI	h-index	C3PO	PI-BETA	Eigenfactor	Immediacy	Article Influence	CAI	H-STAR	2Y-STAR
2YIF	1.000												
2YIF*	0.998	1.000											
5YIF	0.967	0.967	1.000										
IFI	-0.170	-0.219	-0.195	1.000									
h-index	0.541	0.542	0.591	-0.186	1.000								
C3PO	0.467	0.481	0.554	-0.164	0.588	1.000							
PI-BETA	0.149	0.147	0.121	-0.044	-0.191	-0.344	1.000						
Eigenfactor	0.426	0.417	0.406	-0.060	0.173	-0.076	0.137	1.000					
Immediacy	0.880	0.870	0.838	-0.096	0.447	0.182	0.232	0.475	1.000				
Article Influence	0.888	0.895	0.936	-0.230	0.508	0.622	0.021	0.378	0.745	1.000			
CAI	0.745	0.754	0.804	-0.211	0.533	0.785	-0.272	0.228	0.556	0.919	1.000		
H-STAR	0.274	0.324	0.313	-0.880	0.282	0.262	0.058	0.085	0.167	0.360	0.326	1.000	
2Y-STAR	0.312	0.364	0.339	-0.888	0.251	0.285	0.064	0.074	0.185	0.389	0.358	0.962	1.000

Note: Citations data were downloaded from ISI on 4 June 2010 for 1988-2010. As there is an overlap of 8 journals across the 20 ISI categories, there are 112 distinct journals.