The focus factor

Nicolaisen, Jeppe; Frandsen, Tove Faber

Published in:
Information Research. An International Electronic Journal

Publication date:
2015

Citation for published version (APA):
Nicolaisen, J., & Frandsen, T. F. (2015). The focus factor: A dynamic measure of journal specialisation. Information Research. An International Electronic Journal, 20(4).

informationresearch

VOL. 20 NO. 4, DECEMBER, 2015

The focus factor: a dynamic measure of journal specialisation

Jeppe Nicolaisen
University of Copenhagen, Birketinget 6, DK-2300 Copenhagen S., Denmark
Tove Faber Frandsen
Odense University Hospital, Søndre Boulevard 29, DK-5000 Odense, Denmark

Introduction. *We present a new bibliometric indicator to measure journal specialisation over time, named the focus factor. This new indicator is based on bibliographic coupling and counts the percentage of re-citations given in subsequent years.*
Method. *The applicability of the new indicator is demonstrated on a selection of general science journals and on a selection of medical journals. The reference lists of each journal are compared year by year, and the percentage of re-citations is calculated by dividing the number of re-citations with the total number of citations each year.*
Analysis. *To validate re-citations as caused by specialisation, other possible causes were measured and correlated (obsolescence, journal self-citations and number of references).*
Results. *The results indicate that the focus factor is capable of distinguishing between general and specialised journals and thus effectively measures the intended phenomenon (i.e., journal specialisation). Only weak correlations were found between journal re-citations and obsolescence, journal self-citations, and number of references.*
Conclusions. *The focus factor successfully measures journal specialisation over time. Measures based on either simple citation analysis or bibliographic coupling are found*

to be close relatives. Measures based on journal self-citation are found to be only weakly correlated with the focus factor. Measures based on co-citation analysis remain to be studied and compared.

change font

Introduction

The Philosophical Transactions of the Royal Society of London is commonly referred to as the first scientific journal. It was published for the first time in 1665, three months later than the French *Journal des Scavans*. Both journals published scientific information, but *Journal des Scavans* focused more on reviewing books than on communicating new research in article form (Meadows, 1974). These two journals, and the journals that subsequently followed, originated as the public record of the activities and interests of learned societies. Journals unrelated to scientific societies began to emerge during the eighteenth and nineteenth centuries (Meadows, 1974). As a response to the rapid increase in new research results during the nineteenth century, scientists began to specialise in sub-disciplines. Scientists were no longer able to follow the development in their own discipline as a whole, but focused instead on smaller disciplinary fractions. This development also led to the increasing specialisation of many scientific journals (Meadows, 1974).

Thus, for a long time the scientific journal has been the most important media for communicating new ideas and knowledge in science, in most of the social sciences, and to a lesser, but growing, extent in the arts and humanities. Perhaps because of this status as the most important media for scientific communication, the scientific journal as a research communication media has caught interest from a number of fields (e.g., history of science, sociology of science, linguistics, library and information science, and others). Yet, the field that has studied the scientific journal the most is undoubtedly bibliometrics. One study immediately springs to mind: Derek J. de Solla Price's seminal discovery of the exponential growth of science that was based on studies of the oldest scientific journal (*Philosophical Transactions*) and other journals (Price, 1963). Countless other bibliometric studies focusing on the scientific journal have followed (too many to mention here). Some of these studies have sought to establish adequate citation-based measures for various aspects of the scientific journal. Among the most prominent of these are Burton and Kebler's (1960) study, in which they developed a measure of the obsolescence of scientific literature (the half-life), later used for measuring the obsolescence of scientific journals (e.g., The Journal Citation Reports); and Garfield and Sher's (1963) study, in which they developed the journal impact factor. Many alternative measures of journal obsolescence and journal impact have been developed since the 1960s, but a vital aspect of the scientific journal has thus far been largely overlooked or ignored by this line of bibliometric indicator research: journal specialisation. It is actually a bit curious since bibliometricians have long known about the important factor of specialisation for the outcome of bibliometric studies. Almost forty years ago, Henry Small pointed to the principal finding of experiments conducted one to two years before by leading bibliometricians including, amongst others, Eugene Garfield, Belver C. Griffith and himself, and concluded that *the primary structural unit in science is the scientific specialty* (Small, 1976, p. 67). A common critique of the journal impact factor is that the impact factor of a journal is partly determined by its level of specialisation (e.g., Seglen, 1997). Thus, to improve our interpretation of bibliometric journal indicators (e.g., the journal impact factor), we need a simple yet effective measure of journal specialisation. One that could be readily incorporated into products like, for example, The Journal Citation Reports.

Nicolaisen and Frandsen (2013) developed a simple yet effective measure for measuring the specialisation of scientific journals. They presented the idea for this new citation-based measure at the CoLIS8-conference in Copenhagen in 2013 (Nicolaisen and Frandsen, 2013) and as a brief communication published in the

Journal of the Association for Information Science and Technology (Nicolaisen and Frandsen, 2015). Having tested the measure on a larger sample, we present a more detailed investigation of the new measure. Specialisation equals narrowing one's focus and we have therefore chosen to name the new citation-based journal measure *the focus factor*.

The next section provides a detailed description of the focus factor including the basic theoretical assumptions it rests upon, related measures and how it is calculated. In subsequent sections we then demonstrate the application of the new indicator on a selection of scientific journals and test its validity as a measure of journal specialisation.

Related literature and measures

The new citation-based measure that we are about to present is a measure of journal specialisation. It is based on the common definition of scientific specialities and specialisation that may be found in many texts on the sociology of science and science studies (including bibliometrics). Before we present the focus factor in more detail, we will briefly outline this common understanding and definition, and briefly touch upon related bibliometric measures.

Specialities and specialisation

In his book *Communicating research*, Meadows (1998) discusses, among other things, the rapid growth of scientific research and how the research community has developed a mechanism for coping with the excessive information output. This mechanism is, according to Meadows (1998, p. 20), specialisation. To understand exactly what he means by specialisation, one has to examine his argument somewhat further. Meadows (1998, p. 19) asks the reader to listen to Faraday's complaint from 1826:

> *It is certainly impossible for any person who wishes to devote a portion of his time to chemical experiment, to read all the books and papers that are published in connection with his pursuit; their number is immense, and the labour of winnowing out the few experimental and theoretical truths which in many of them are embarrassed by a very large proportion of uninteresting matter, of imagination, and error, is such, that most persons who try the experiments are quickly induced to make a selection in their reading, and thus inadvertently, at times, pass by what is really good.*

Today there is much more information to cope with than in the days of Faraday. Therefore, one could consequently be led to believe that the problem which Faraday described is much worse in our time. However, according to Meadows (1998), it is not. The reason is that modern chemists no longer try to command what Meadows (1998, p. 20) terms *the same broad sweep of their subject* as chemists did in Faraday's time. Modern chemists concentrate instead on much more restricted topics (Meadows, 1998, p. 20). Researchers have become much more *specialised* (Meadows, 1998, p. 20). As research has expanded, researchers have confined their attention to selected parts of it (Meadows, 1998, p. 20). Members of a discipline are therefore typically interested in only part of the field (Meadows, 1998, p. 21).

This definition of specialities resembles the idea of a social division of labour in society. In all known societies the production of goods and services is divided into different work tasks, in such a way that none of the members of a society conduct all tasks. On the contrary, the types of work tasks which an individual may conduct are often regulated by rules and individuals are often obliged to conduct certain tasks. Adam Smith (1723-1790) was the first to formulate how the social division of labour leads to increased productivity. In his book, *On the wealth of nations*, published in 1776, he even maintains that division of labour is the most important cause of economic growth. A famous example from the book illustrates his point. The example concerns a pin factory. According to Smith, a pin factory that adopts a division of labour may produce tens of thousands of pins a day, whereas a pin factory in which each worker attempt to produce pins from start to finish, by performing all the tasks associated with pin production will produce very few pins. What Meadows (1998) seems to have in mind when describing the strategy adopted by modern chemists is thus the strategy of a successful pin factory. Like the workers of a successful pin factory, modern chemists have divided their work tasks between them and are consequently working on different, but related, tasks. Today, there are several specialities in chemistry, including organic chemistry, inorganic chemistry, chemical engineering and many more. The same holds true for all other scientific fields. Sociologists, for instance, usually work within one of the specialities described in Smelser's (1988) *Handbook of sociology*. These include, among others, the sociology of education, the sociology of religion, the sociology of science, medical sociology, mass media sociology, sociology of age and sociology of gender and sex.

Meadows (1998, p. 44) mentions that disciplines and specialities also can be produced by fusion. The combination of part of biology with part of chemistry to produce biochemistry is just one example.

Consequently, what characterises a speciality is the phenomenon or phenomena which members of the speciality study. Organic and inorganic chemistry, for instance, are different specialities because the researchers in these specialities study different phenomena. Organic chemists study materials that are carbon based, such as oil or coal, while inorganic chemists work with materials that contain no carbon or carbon-based synthetics. Sociologists of science study scientific societies while sociologists of religion study religious societies. Though most of the members of these two groups have been trained in the discipline of sociology, they belong to different sociological specialities because they study different sociological phenomena.

As noted above, Meadows' definition of specialities corresponds to the definition usually employed in science studies. Crane and Small (1992, p. 198), for instance, explain the concept of specialities by arguing that:

> *clusters of related research areas constitute specialties whose members are linked by a common interest in a particular type of phenomenon or method (such as crime, the family, population, etc.). Disciplines, in turn, are composed of clusters of specialties*

Small and Griffith (1974, p. 17) maintain that *'science is a mosaic of specialties, and not a unified whole'*, and note that specialities are the *building blocks* of science. Gieryn (1978), Whitley (1974) and Zuckerman (1978) claim that a problem area is made up of a number of related though discrete problems, that a cluster of related problem areas comprise a speciality, and that a scientific discipline covers a set of related specialities.

Measuring specialisation

Hagstrom (1970, p. 91-92) argues that *'it is reasonable to believe that scientists will communicate most often and intensively with others in their specialties, exchanging preprints with them, citing their work, and exchanging reprints'*. Ziman (2000, p. 190) notes that *'scientific specialties often seem to be shut off from one another by walls of mutual ignorance'*. These assumptions have been explored and confirmed empirically by bibliometricians.

Using simple citation analysis, Earle and Vickery (1969) investigated to what extent a variety of subject areas drew on the literature of their own area (subject self-citation) and other subject areas. They found considerable variations among the subject areas under study, which seem to fit with the assumptions regarding specialisation. Among their findings was that considerable dependence on other subject areas was found in the general science and general technology areas, whereas mathematics was found to depend little on literature from other subject areas.

Author self-citations have also been found to reflect specialisation tendencies. Often, author self-citations are frowned upon by critics of citation analysis (e.g., Seglen, 1992; MacRoberts and MacRoberts, 1989; 1996). The critics speculate or even claim (see Seglen, 1992, p. 636) that author self-citations are equal to self-advertising and, thus, that author self-citations should be eliminated from evaluative bibliometrics. Yet a study of fifty-one self-citing authors conducted by Bonzi and Snyder (1991) revealed essentially no differences between the reasons that authors cite their own work and the reasons they cite the work of others. The self-citations predominantly identified related work or earlier work that later works were built upon. Thus, author self-citations seem to indicate an author's specialised focus on a narrow scientific problem. Early studies by Parker, Paisley and Garrett (1967) and Meadows and O'Conner (1971) also documented similar relations between specialisation and author self-citations.

Marshakova (1973) and Small's (1973) co-citation technique provides a quantitative technique for grouping or clustering cited documents or cited authors. By measuring the strength of co-citation in a large enough sample of units (e.g., documents or authors) it is possible to detect clusters of units, which are highly co-cited. The information scientists, who became interested in this technique during the 1970s and onward, have repeatedly found that such clusters adequately represent scientific specialities (e.g., Small and Griffith, 1974; White and Griffith, 1981; White and McCain, 1998; Zhao and Strotmann, 2014).

Bibliographic coupling (Kessler, 1963) is a related method for clustering related entities. Documents (or other units of analysis) are said to be bibliographically coupled if they share bibliographic references. Bibliometricians began to take an interest in this technique during the 1990s, using it for identifying and mapping clusters of subject-related documents (e.g., Glänzel and Czerwon, 1996; Jarneving, 2007; Ahlgren and Jarneving, 2008). As shown by Nicolaisen and Frandsen (2012), bibliographic coupling has another promising potential as a measure of the level of consensus and specialisation in science. Using a modified form of bibliographic coupling (aggregated bibliographic coupling), they were able to measure the level of consensus in two different disciplines at a given time.

The focus factor

Specialisation is a process. The level of specialisation within a discipline probably increases or decreases over time. To measure this by bibliometric methods such as self-citations, co-citation analysis or bibliographic coupling, a time dimension needs to be included. The focus factor is created with this purpose in mind. Using the scientific journal as sample unit, it measures the level of specialisation by calculating overlaps in bibliographic references year by year. For example: a journal produces 1,536 references in year zero and 1,622 references in year one, 219 of which are found in the reference lists of the journal in both years. Thus, 219 out of 1,622 references in year one are similar to references found in the same journal the preceding year. This equals 13.5%, and is taken as an indicator of the level of specialisation in that particular journal in year one. The level of specialisation in year two is calculated by comparing the overlap in bibliographic references used by the same journal in year one and year two, and so on.

The method was tested by Nicolaisen and Frandsen (2013; 2015) on a selection of core journals in library and information science. The results showed that the focus factor distinguishes satisfactorily between general journals and speciality journals, and, moreover, effectively measures the level of specialisation among the selected journals.

Method

To examine the applicability of the focus factor on a wider variety of subjects and journals we have tested the measure on a selection of general science journals, general medical journals and specialised medical journals (see table 1). The general science journals include journals such as *Science*, *Nature* and *PNAS* (see, e.g., Fanelli, 2010), of which the two first mentioned are selected for the present study. The general medical journals selected for this study are among the most prestigious medical journals (see, e.g., Choi, Nakatomi and Wu, 2014) also known as the big five (e.g., Wager, 2005). The specialised medical journals are selected as examples from a wide range of specialist journals available on the basis of advice from two medical information specialists (MD and MSC).

General science journals
Science
Nature
General medical journals
British Medical Journal
The Journal of the American Medical Association
Annals of Internal Medicine
Lancet
New England Journal of Medicine
Specialised medical journals
Ophthalmology
Archives of Ophthalmology
American Journal of Ophthalmology
British Journal of Ophthalmology
Experimental Eye Research
Investigative Ophthalmology
Journal of Clinical Oncology
JNCI: Journal of the National Cancer Institute

Table 1. List of included journals

In order to determine the share of re-citations, the references in a specific year of each of the included journals were compared to the references in the journal in the previous year. A re-citation is defined as a 100%match between a cited reference in one year to a cited reference the previous year. This means that spelling errors, typing errors, variations of spelling and similar irregularities are potential sources of bias, but as they are expected to be evenly distributed across the data set, bias is unlikely. Data registered is name of journal, publication year, cited references in the journal and the number of instances for every reference. Some of the references appear more than once and consequently the number of re-citations depends on the total number of instances and not just the number of unique references. Information on journal, publication year and cited references in the journal was collected using Web of Science. Information on the number of instances for every reference was gathered using software developed for this specific purpose. The share of re-citations in journal j in year y is calculated as follows:

Share of re-citations = number of re-citations (j,y) / total number of references (j,y)

The following is an example of how share of re-citations is calculated: in 2011 Nature contained 32,069 references of which 4,971 were re-citations, resulting in a share of re-citations of 4,971 / 32,069 = 0.155.

In total this study analysed 4,788,579 references in 15 journals from 1991 to 2012 and calculated the re-citation share. Only articles, notes, reviews and letters were included. Letters are included as recommended by Christensen et al. (1997).

Results

The journals included in the analyses are specialised to a varying degree. The share of re-citations varies from 0.05 to more than 0.2, i.e. about 20%of the references in any given year appeared in that specific journal the previous year. Figures 1 and 2 are illustrations of the development in levels of specialisation from 1991 to 2012. For specific counts, see appendix.

Figure 1 presents the results of the analyses of the general science journals and the general medical journals.

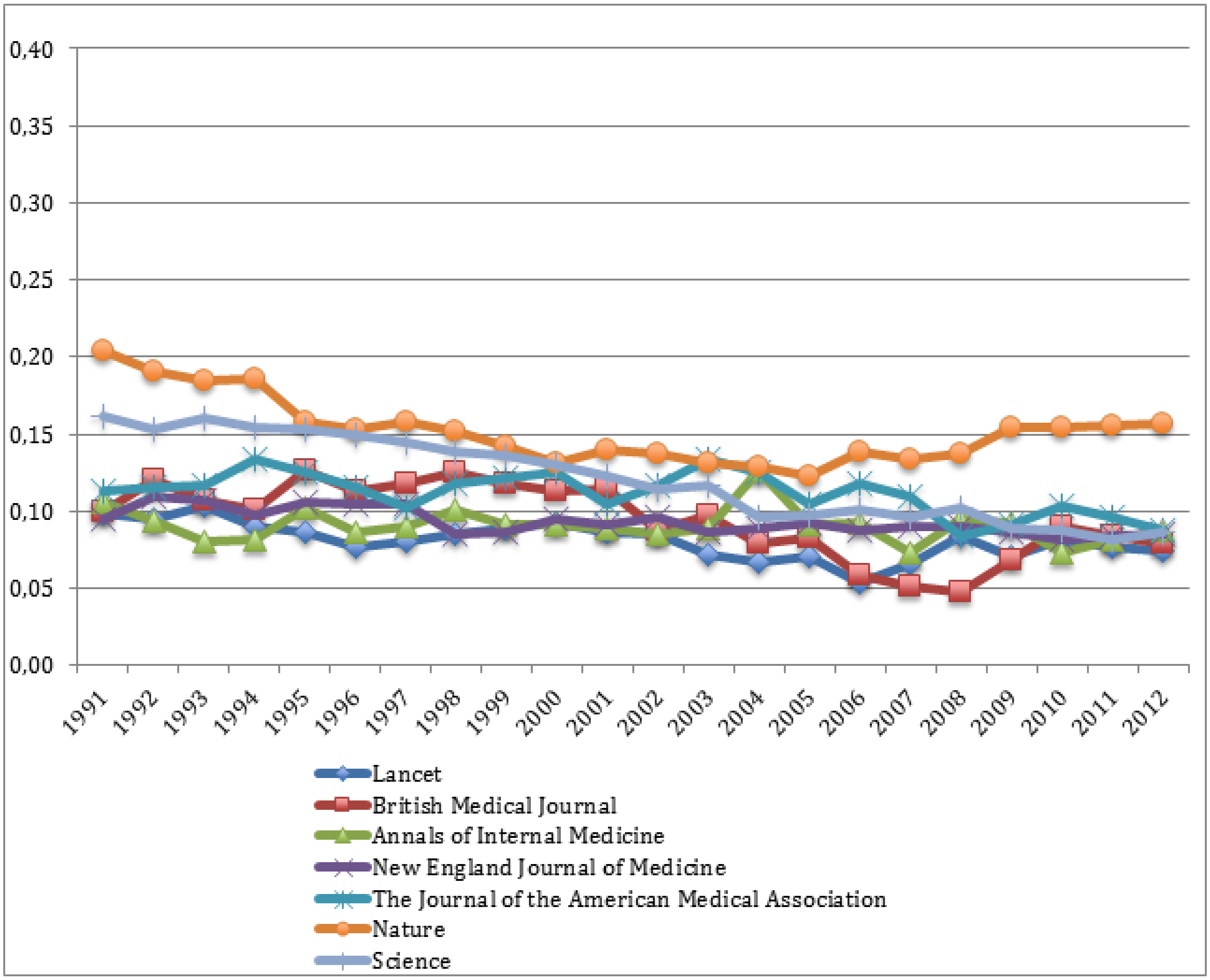

Figure 1: Level of specialisation (general science journals and general medical journals)

One journal stands out in this figure as it is characterised by a greater extent of specialisation, particularly in the last five to six years. Nature appears to be more highly specialised than the other journals depicted in figure 1. This tendency seems to decrease during the first decade of analysis, but increases during the last. The other general journal, Science, on the other hand also starts out highly specialised but moves towards less specialisation during the entire period.

Figure 2 provides an overview of the results of the analyses of the specialised medical journals. To be able to compare the results, the units on the horizontal axes of figures 1 and 2 are the same.

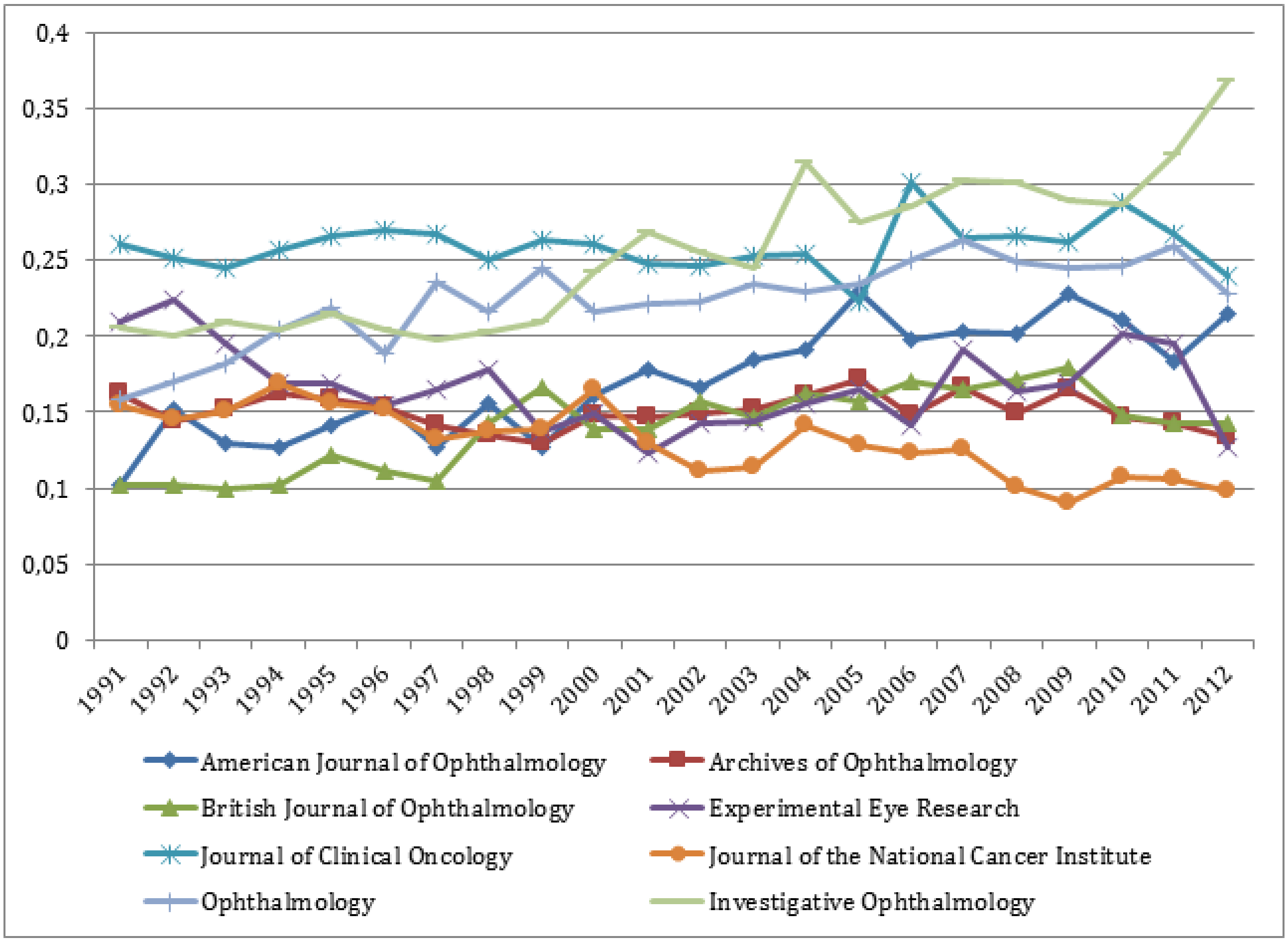

Figure 2: Level of specialisation (specialised medical journals)

The specialised medical journals show great variation with a share of re-citations ranging from 0.10 to 0.37. Some are specialised at a level resembling more general journals, whereas for other journals 30% of the references in some years appeared in that specific journal the previous year.

Nicolaisen and Frandsen (2013) analysed whether the levels of re-citations can be explained by obsolescence. They tested the hypothesis by examining the age distribution of the references in the journal, measured by the half-life or median citation age. A discrete analysis method was applied as publication years were treated as discrete units not a continuum of dates in terms of intervals. The correlation was positive, i.e. journals including a relatively large share of older references are characterised by a greater level of specialisation – all other things equal. Journals with relatively recent references have fewer re-citations simply because there are more references in those journals that could not have been cited the year before. The hypothesis is also tested on this data, yielding a similar result. Figure 3 provides an illustration of the correlation and, parallel to the previous analysis, the r-squared indicates that median citation age alone does not explain the different levels of re-citation. For specific counts, see appendix.

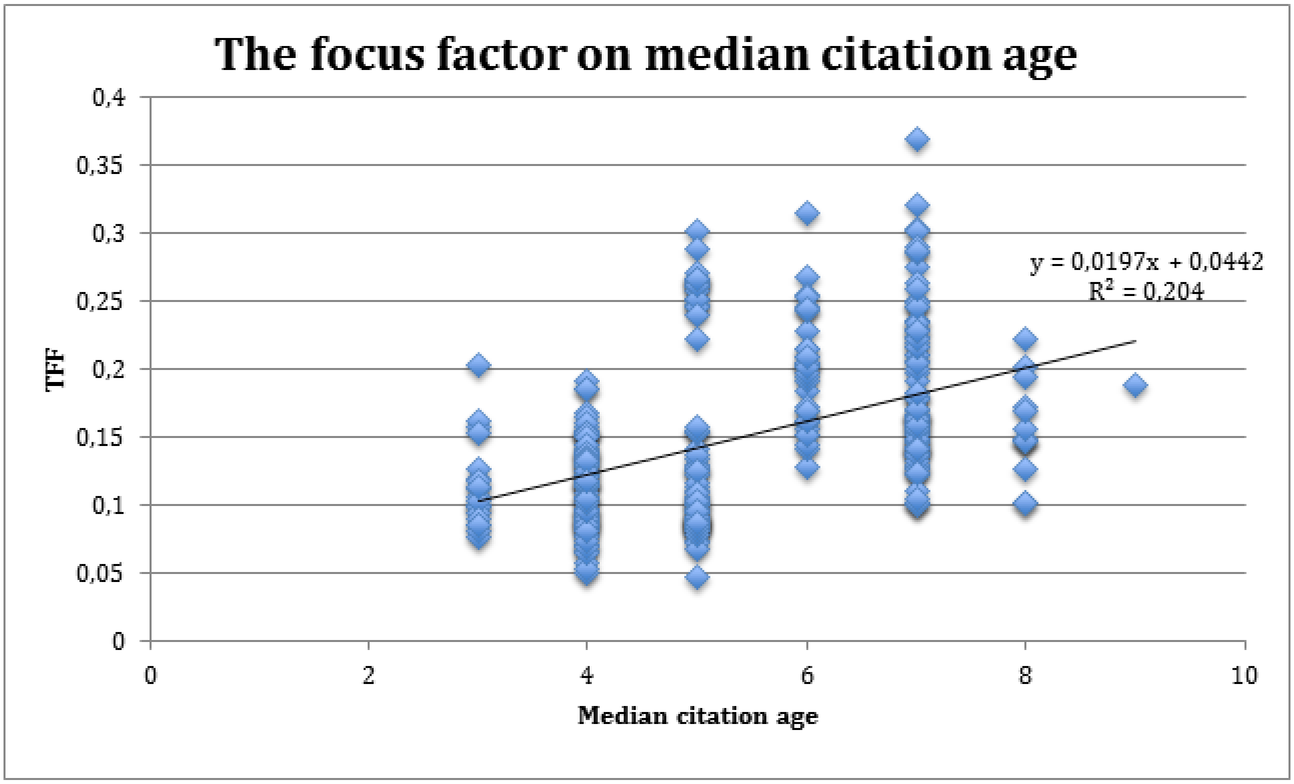

Figure 3: The median citation age and share of re-citations

Turning to another commonly used measure for specialisation that could potentially explain the differences in levels of re-citation, we will now analyse the correlation between share of re-citations and journal self-citations. Share of self-citations is measured for each journal in the entire time period and correlated with share of re-citations. Figure 4 depicts some correlation, although definitely not a very strong one. For specific counts, see appendix.

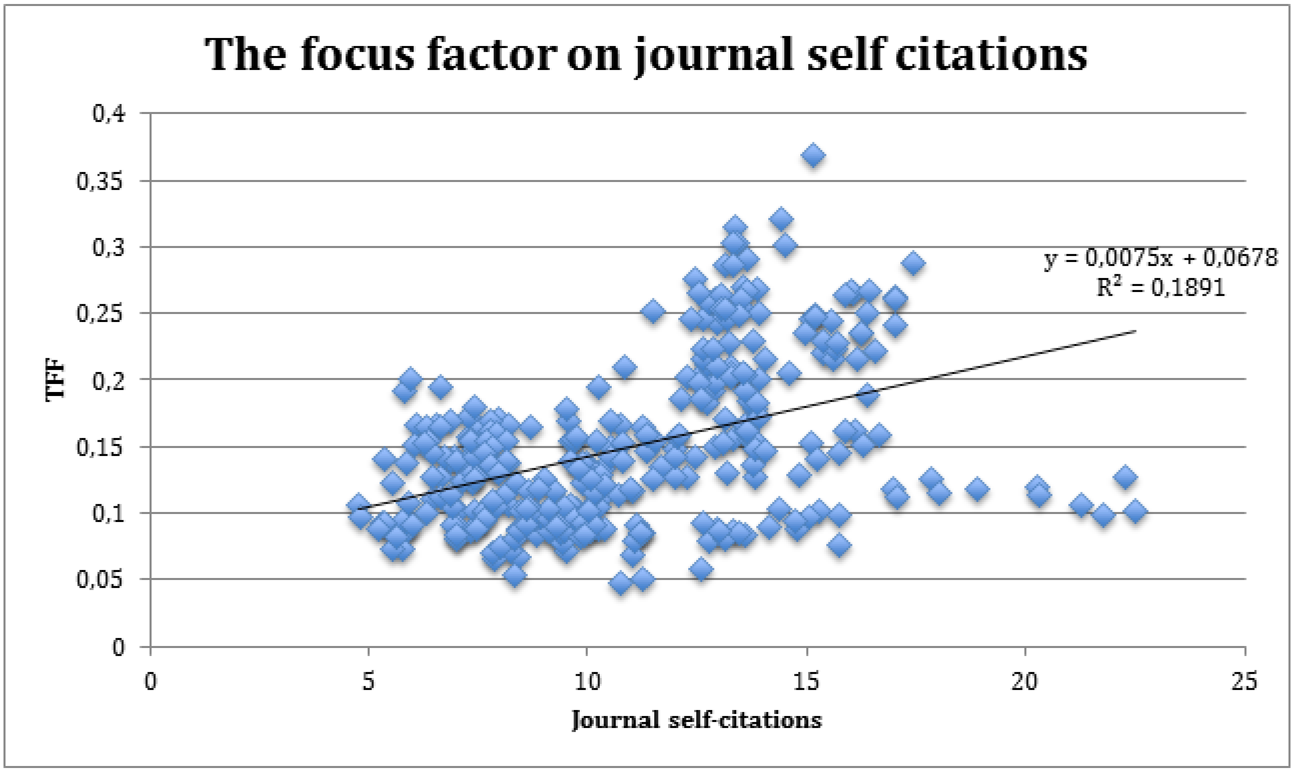

Figure 4: Journal self-citations and share of re-citations

The r-squared value of 0.19 confirms that journal self-citations and share of re-citations are not to be considered similar measures.

Finally, we examine whether the differences in levels of re-citation are caused by differences in number of references. Some might argue that larger journals have more references that may be re-cited. However, the measure is not absolute and consequently larger journals should not be exhibiting higher levels of re-citation. Share of self-citations is measured for each journal in the entire time period and correlated with the total number of references during that year.

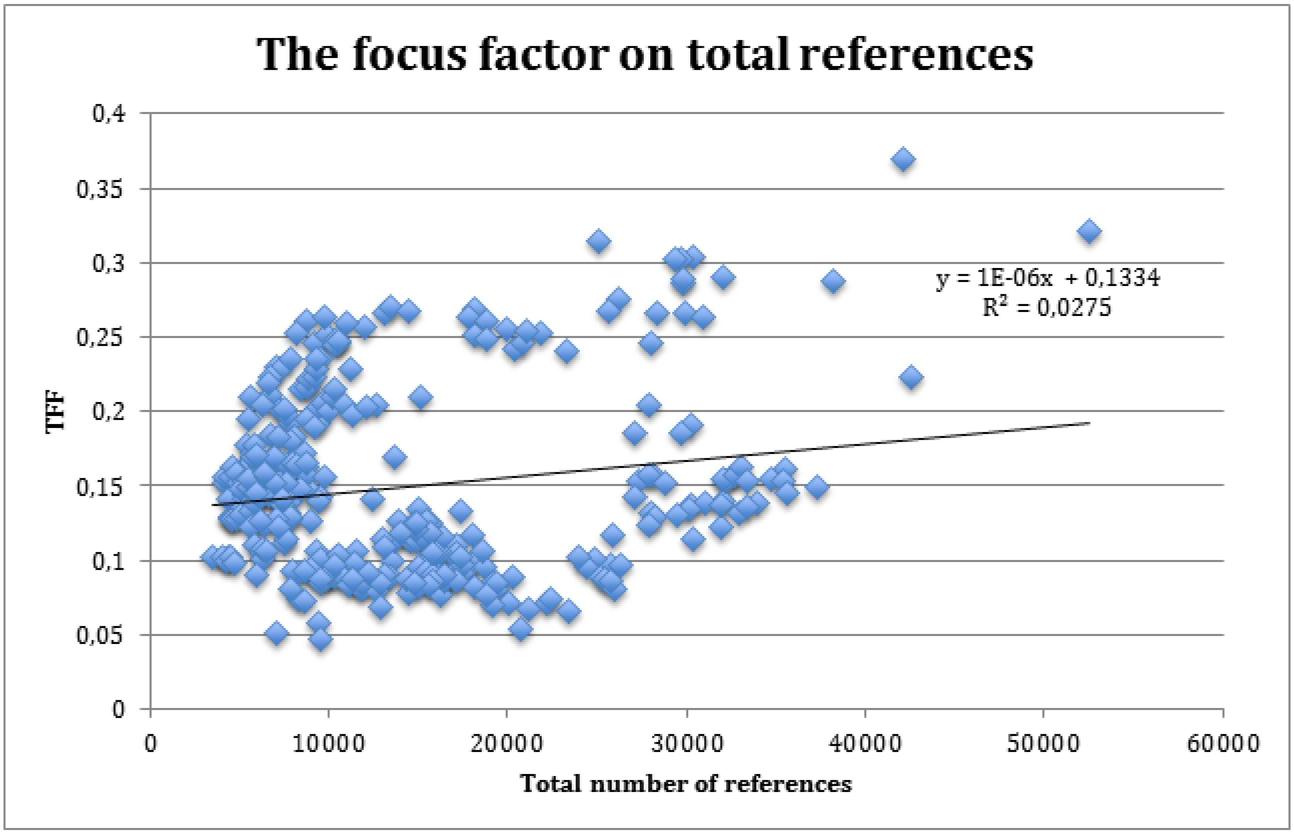

Figure 5: Number of references and share of re-citations

Figure 5 depicts very weak correlation between the number of references and share of re-citations. For specific counts, see appendix.

Discussion and conclusion

Scientific journals serve several purposes. Among the most important of these are credit, dissemination and archiving of research results. Although scientific journals may be said to share vital characteristics, the way they serve their purposes, the means by which they seek to serve them, and their success in serving them, are at best diverse. Thus, seeking to develop a single and unique measure of scientific journals is impossible. As noted by Rousseau (2002), the quality of a journal is a multifaceted notion necessitating a whole battery of indicators. The focus factor is a new contribution to this battery of indicators.

Measuring the level of specialisation is a novelty in bibliometric indicator research. We believe that the level of specialisation is an important aspect of scientific journals. Yet, like other indicators, the focus factor measures only one aspect of scientific journals and only becomes interesting when other aspects are taken into account as well. Moreover, like other indicators, a single meter reading cannot be taken as definite proof. The measure should be applied over time, resulting in several meter readings that should be compared with readings from other journal indicators. Only by this approach may we get an adequate picture of a scientific journal.

When measuring the overall level of specialisation in the two groups of journals, the focus factor is quite capable of distinguishing between general and specialised groups of journals. The general journals presented in figure 1 show figures in the range of 0.05 to around 0.2. The specialised journals presented in figure 2 show figures in the range of 0.1 to 0.35. Yet we find overlapping meter readings in the two groups of journals (between 0.1 and 0.2). Focusing specifically on *Nature*, we find what appears to be a somewhat more specialised journal. Yet, *Nature* is normally said to be a general science journal. Logically, either the focus factor is failing or the assessment of *Nature* as being a general science journal *per se* is wrong. We believe the latter is the case. When applying the focus factor to a selection of library and information science journals, Nicolaisen and Frandsen (2013) found a similar deviant: *Journal of the Association for Information Science and Technology* (JASIST). When measuring the level of specialisation using the focus factor, they found that *JASIST* generally had higher scores than most of the specialised journals in the field. *JASIST* is a journal that seeks to cover the field at large and would therefore normally be said to be a general journal. Looking a bit deeper into this apparent anomaly, Nicolaisen and Frandsen (2015) found that the high scores of *JASIST* were mainly caused by a large corpus of bibliometric papers published in *JASIST*. Thus, they found that it was not a failure of the focus factor, but instead that *JASIST* over time has shifted its focus more toward bibliometrics, thus becoming gradually more and more specialised. The same is probably the case with *Nature*. A deeper study will probably reveal a couple of favourite topics of the journal (e.g., cell biology, nuclear physics, astrophysics or even anthropology) leading to a corpus of specialised papers with higher degrees of re-citations. An important consequence of these findings is that the binary notion of general and specialised journals is probably too limiting. In reality, a much richer scale exists.

Previously, specialisation has been measured using other measures:

1. Simple citation analysis (Earle and Vickery, 1969)
2. Author self-citations (Parker, Paisley and Garrett, 1967; Meadows and O'Conner, 1971)
3. Co-citation (e.g., Small and Griffith, 1974; White and Griffith, 1981; White and McCain, 1998; Zhao and Strotmann, 2014)
4. Bibliographic coupling (e.g., Glänzel and Czerwon, 1996; Jarneving, 2007; Ahlgren and Jarneving, 2008; Nicolaisen and Frandsen, 2012)

To some extent, the focus factor may be seen as a further development of 1 and 4. Instead of focusing on subject areas and the extent to which they rely on own literature (as Earle and Vickery (1969) did), the focus factor focuses on scientific journals and the extent to which they rely on own literature (defined as literature used and cited the year before). Clearly, such a relation is equal to a bibliographic coupling. Thus, the finding that the focus factor is an adequate measure of scientific specialisation was expected. Likewise, measuring the level of specialisation by journal self-citation was also expected to perform well. However, although we are able to document some correlation between journal re-citation and share of journal self-citation, these measures should not be considered the same.

Finally, it is worth noticing that the scientific communication system is continually changing. New media of communication are constantly surfacing (e.g., mega-journals like PLOS ONE) and readers are provided with new tools for finding and keeping up to date with the developments in their fields of interest (e.g., RSS feeds, searching Google Scholar, etc.), making the context of the journal less visible (e.g., Lozano, Larivière and Gingras, 2012). Journal indicators like the focus factor are of course only relevant indicators as long as the scientific journal remains the preferred medium for scientific communication.

Acknowledgements

The authors would like to thank David Hammer and Anne Poulsen for their competent assistance with data collection, and the two anonymous referees for their valuable suggestions for improvements.

About the authors

Jeppe Nicolaisen is associate professor at University of Copenhagen. He received his PhD in library and information science from the Royal School of Library and Information Science, Copenhagen, Denmark. He can be contacted at: Jep.nic@hum.ku.dk
Tove Faber Frandsen is head of *Videncentret* at Odense University Hospital, Denmark. She received her PhD in library and information science from the Royal School of Library and Information Science, Copenhagen, Denmark. She can be contacted at: t.faber@videncentret.sdu.dk

Ahlgren, P. & Jarneving, B. (2008). Bibliographic coupling, common abstract stems and clustering: a comparison of two document-document similarity approaches in the context of science mapping. *Scientometrics, 76*(2), 273-290.

Bonzi, S. & Snyder, H.W. (1991). Motivations for citation: a comparison of self citation and citations to others. *Scientometrics*, *21*, 245-254.

Burton, R.E. & Kebler, R.W. (1960). The half-life of some scientific and technical literatures. *American Documentation*, *11*(1), 18-22.

Choi, Y.M., Nakatomi, D. & Wu, J.J. (2014). Citation classics and top-cited authors of psoriasis in five high-impact general medical journals, 1970-2012. *Dermatology Online Journal, 20*(5). Retrieved from http://escholarship.org/uc/item/69n5m3v6#page-1 (Archived by WebCite® at http://www.webcitation.org/6bBqgz8lr)

Christensen, F.H., Ingwersen, P. & Wormell, I. (1997). Online determination of the journal impact factor and its international properties.

Scientometrics, 40(3), 529-540.

Crane, D. & Small, H. (1992). American sociology since the seventies: the emerging identity crisis in the discipline. In T.C. Halliday & M. Janowitz (Eds.). *Sociology and its publics: the forms and fates of disciplinary organization* (pp. 197-234). Chicago, IL: University of Chicago Press.

de Solla Price, D.J. (1963). *Little science, big science*. New York, NY: Columbia University Press.

Earle, P. & Vickery, B. (1969). Subject relations in science/technology literature. *Aslib Proceedings, 21*(6), 237-243.

Fanelli, D. (2010). "Positive" results increase down the hierarchy of the sciences. *PLOS One, 5*(4). Retrieved from http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010068 (Archived by WebCite® at http://www.webcitation.org/6bBqIKtHl)

Garfield, E. & Sher, I.H. (1963). New factors in the evaluation of scientific literature through citation indexing. *American Documentation, 14*(3), 195-201.

Gieryn, T.F. (1978). Problem retention and problem change in science. *Sociological Inquiry, 48*(3-4), 96-115.

Glänzel, W. & Czerwon, H.J. (1996). A new methodological approach to bibliographic coupling and its application to the national, regional and institutional level. *Scientometrics, 37*(2), 195-221.

Hagstrom, W.O. (1970). Factors related to the use of different modes of publishing research in four scientific fields. In C.E. Nelsen & D.K. Pollock (Eds.), *Communication among scientists and engineers* (pp. 85-124). Lexington, MA: Lexington Books.

Jarneving, B. (2007). Bibliographic coupling and its application to research-front and other core documents. *Journal of Informetrics, 1*(4), 287-307.

Kessler, M.M. (1963). Bibliographic coupling between scientific papers. *American Documentation, 14*(1), 10-25.

Lozano, G.A., Lariviére, V. & Gingras, Y. (2012). The weakening relationship between the impact factor and papers' citations in the digital age. *Journal of the American Society for Information Science and Technology, 63*(11), 2140-2145.

MacRoberts, M.H. & MacRoberts, B.R. (1989). Problems of citation analysis: a critical review. *Journal of the American Society for Information Science, 40*(5), 342-349.

MacRoberts, M.H. & MacRoberts, B.R. (1996). Problems of citation analysis. *Scientometrics, 36*(3), 435-444.

Marshakova, I.V. (1973). A system of document connection based on references. *Scientific and Technical Information Serial of VINITI, 6*(2), 3-8.

Meadows, A.J. (1998). *Communicating research*. San Diego, CA: Academic Press.

Meadows, A.J. (1974). *Communication in science*. London: Butterworth.

Meadows, A.J. & O'Connor, J.G. (1971). Bibliographical statistics as a guide to growth points in science. *Social Studies of Science, 1*(1), 95-99

Nicolaisen, J. & Frandsen, T.F. (2013). Core journals in library and information science: Measuring the level of specialisation over time. *Information Research, 18*(3), paper S05. Retrieved from http://InformationR.net/ir/18-3/colis/paperS05.html (Archived by WebCite® at http://www.webcitation.org/6ahaxXJzO)

Nicolaisen, J. & Frandsen, T.F. (2015). Bibliometric evolution: is the Journal of the Association for Information Science and Technology transforming into a specialty journal? *Journal of the Association for Information Science and Technology, 66*(5), 1082-1085.

Nicolaisen, J. & Frandsen, T.F. (2012). Consensus formation is science modeled by aggregated bibliographic coupling. *Journal of Informetrics, 6*(2), 276-284.

Parker, E.B., Paisley, W.J. & Garrett, R. (1967). *Bibliographic citations as unobtrusive measures of scientific communication*. San Francisco, CA: Stanford University.

Rousseau, R. (2002). Journal evaluation: technical and practical issues. *Library Trends, 50*(3), 418-439.

Seglen, P.O. (1992). The skewness of science. *Journal of the American Society for Information Science, 43*(9), 628-638.

Seglen, P.O. (1997). Why the impact factor of journals should not be used for evaluating research. *British Medical Journal, 314*(7079), 498-502.

Small, H. (1973). Co-citation in the scientific literature: a new measurement of the relationship between two documents. *Journal of the American Society of Information Science, 24*(4), 265-269.

Small, H. & Griffith, B.C. (1974). The structure of scientific literatures 1: identifying and graphing specialties. *Science Studies, 4*(1), 17-40.

Small, H.G. (1976). Structural dynamics of scientific literature. *International Classification, 3*(2), 67-74.

Smelser, N.J. (Ed.). (1988). *Handbook of sociology*. Newbury Park, CA: Sage Publications.

Wager, E. (2005). *Getting research published: an A-Z of publication strategy*. Oxford: Radcliffe.

White, H.D. & Griffith, B.C. (1981). Author cocitation: a literature measure of intellectual structure. *Journal of the American Society for Information Science, 32*(3), 163-171.

White, H.D. & McCain, K.W. (1998). Visualizing a discipline: an author co-citation analysis of information science, 1972-1995. *Journal of the American Society for Information Science, 49*(4), 327-355.

Whitley, R. (1974). Cognitive and social institutionalisation of scientific specialties and research areas. In R. Whitley (Ed.), *Social processes of scientific development* (pp. 69-95). London: Routledge and Kegan Paul.

Zhao, D.Z. & Strotmann, A. (2014). The knowledge base and research front of information science 2006-2010: an author cocitation and bibliographic coupling analysis. *Journal of the Association for Information Science and Technology, 65*(5), 995-1006.

Ziman, J.M. (2000). *Real science: what it is, and what it means*. Cambridge: Cambridge University Press.

Zuckerman, H. (1978). Theory choice and problem choice in science. *Sociological Inquiry*, *48*(1), 65-95.

Nicolaisen, J. & Frandsen, T.F. (2015). The focus factor: a dynamic measure of journal specialisation. *Information Research, 20*(4), paper 693. Retrieved from http://InformationR.net/ir/20-4/paper693.html (Archived by WebCite® at http://www.webcitation.org/6cduJHSF8)

Appendix

American Journal of Ophthalmology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1991	4361	667	443	0.102	7
1992	4122	622	626	0.152	6
1993	4511	669	582	0.129	6
1994	4482	619	572	0.128	7
1995	4386	545	621	0.142	6
1996	4186	558	653	0.156	6
1997	4574	562	581	0.127	7
1998	4480	613	700	0.156	7
1999	4801	575	610	0.127	7
2000	5268	717	849	0.161	6
2001	5380	744	957	0.178	7
2002	5592	761	929	0.166	7
2003	6748	924	1244	0.184	6
2004	7921	1019	1518	0.192	6
2005	7062	973	1621	0.230	7
2006	7593	980	1503	0.198	7
2007	7041	883	1427	0.203	6
2008	7551	925	1525	0.202	6
2009	7276	963	1660	0.228	6

2010	6697	852	1412	0.211	7
2011	8070	1028	1478	0.183	7
2012	8477	1069	1822	0.215	6

Annals of Internal Medicine

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1991	9382	768	991	0.106	4
1992	10945	839	1031	0.094	5
1993	11877	833	960	0.081	5
1994	11735	830	964	0.082	5
1995	10396	733	1062	0.102	5
1996	9907	725	861	0.087	5
1997	10055	745	902	0.090	5
1998	9518	707	961	0.101	5
1999	9189	644	838	0.091	5
2000	8310	575	755	0.091	5
2001	10333	612	914	0.088	5
2002	9533	553	807	0.085	5
2003	10742	584	958	0.089	5
2004	9036	601	1142	0.126	5
2005	9998	586	918	0.092	5
2006	7984	426	737	0.092	5
2007	8310	478	612	0.074	5
2008	8952	516	845	0.094	5
2009	8625	464	794	0.092	4
2010	8634	480	628	0.073	5
2011	7892	444	641	0.081	5
2012	9579	502	842	0.088	5

Archives of Ophthalmology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	5304	836	766	0.144	6
1993	4911	799	743	0.151	6
1994	4581	728	743	0.162	6
1995	4814	802	765	0.159	7
1996	5281	730	810	0.153	7
1997	5265	803	743	0.141	7
1998	5226	719	708	0.135	7
1999	5025	663	654	0.130	7
2000	5074	702	748	0.147	8
2001	5688	798	837	0.147	8
2002	5561	718	832	0.150	7
2003	6218	813	944	0.152	7
2004	6498	885	1046	0.161	7
2005	5716	794	983	0.172	8

2006	6024	721	895	0.149	8
2007	6154	662	1023	0.166	7
2008	6806	715	1015	0.149	7
2009	6736	759	1111	0.165	7
2010	6467	733	950	0.147	8
2011	5914	709	844	0.143	7
2012	5662	585	755	0.133	7

British Journal of Ophthalmology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	4084	346	415	0.102	8
1993	4315	330	431	0.100	7
1994	4546	348	464	0.102	7
1995	5687	420	693	0.122	7
1996	5852	379	647	0.111	7
1997	6255	432	653	0.104	7
1998	7168	498	1020	0.142	7
1999	6613	432	1098	0.166	7
2000	7283	524	1007	0.138	7
2001	7861	540	1094	0.139	7
2002	7696	572	1208	0.157	8
2003	8968	680	1311	0.146	7
2004	8733	655	1419	0.162	7
2005	8760	636	1382	0.158	7
2006	8277	658	1407	0.170	6
2007	8244	675	1365	0.166	7
2008	8646	630	1485	0.172	6
2009	7873	583	1415	0.180	7
2010	8394	621	1244	0.148	7
2011	9594	729	1367	0.142	7
2012	7133	540	1015	0.142	7

British Medical Journal

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	14323	2900	1718	0.120	3
1993	11621	2473	1238	0.107	3
1994	15556	3501	1572	0.101	3
1995	13888	3094	1759	0.127	3
1996	14636	2972	1661	0.113	4
1997	15562	2942	1828	0.117	3
1998	15719	2801	1973	0.126	4
1999	14533	2465	1722	0.118	4
2000	13650	2331	1536	0.113	3
2001	12999	2344	1487	0.114	4
2002	13440	1985	1184	0.088	4

2003	11495	1729	1121	0.098	4
2004	12710	1624	1001	0.079	4
2005	11117	1511	922	0.083	4
2006	9424	1186	549	0.058	4
2007	7127	803	364	0.051	4
2008	9546	1026	450	0.047	5
2009	12912	1426	885	0.069	5
2010	13139	1460	1189	0.090	5
2011	11880	1339	1004	0.085	5
2012	14456	1600	1136	0.079	5

Experimental Eye Research

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	6773	854	1514	0.224	7
1993	5561	571	1083	0.195	6
1994	5741	605	972	0.169	6
1995	5721	548	969	0.169	7
1996	5650	542	873	0.155	7
1997	7565	658	1246	0.165	7
1998	5896	561	1048	0.178	7
1999	5844	478	805	0.138	7
2000	5569	424	833	0.150	7
2001	6392	457	790	0.124	7
2002	6188	417	880	0.142	7
2003	6660	512	956	0.144	7
2004	9746	751	1518	0.156	7
2005	8022	490	1328	0.166	7
2006	12497	669	1762	0.141	7
2007	9490	551	1818	0.192	7
2008	8245	523	1353	0.164	7
2009	13675	941	2319	0.170	8
2010	9344	555	1881	0.201	8
2011	8770	584	1712	0.195	8
2012	7858	509	998	0.127	8

Investigative Ophthalmology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	10035	1397	2011	0.200	7
1993	10181	1353	2134	0.210	6
1994	12631	1674	2582	0.204	6
1995	10389	1460	2234	0.215	6
1996	10885	1591	2227	0.205	6
1997	11367	1426	2251	0.198	6
1998	12094	1605	2450	0.203	6
1999	15136	1959	3171	0.210	6

2000	20404	2647	4947	0.242	6
2001	18220	2526	4888	0.268	6
2002	20017	2705	5106	0.255	6
2003	28026	3693	6887	0.246	6
2004	25145	3359	7910	0.315	6
2005	26284	3276	7250	0.276	7
2006	29810	3914	8527	0.286	7
2007	30342	4062	9202	0.303	7
2008	29703	3958	8974	0.302	7
2009	32114	4383	9320	0.290	7
2010	38252	5091	10979	0.287	7
2011	52556	7582	16855	0.321	7
2012	42132	6379	15560	0.369	7

Journal of Clinical Oncology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	8251	947	2079	0.252	5
1993	10615	1343	2606	0.246	5
1994	11970	1528	3080	0.257	5
1995	13082	1639	3479	0.266	5
1996	13508	1831	3653	0.270	5
1997	14480	1973	3868	0.267	5
1998	18144	2527	4549	0.251	5
1999	17824	2326	4698	0.264	5
2000	18828	2538	4914	0.261	5
2001	18888	2544	4685	0.248	5
2002	20896	2585	5149	0.246	5
2003	21816	2850	5509	0.253	5
2004	21055	2762	5344	0.254	6
2005	42562	5466	9488	0.223	5
2006	29376	4265	8870	0.302	5
2007	29974	4815	7957	0.265	5
2008	28331	4533	7554	0.267	5
2009	30885	5252	8119	0.263	5
2010	29775	5189	8590	0.288	5
2011	25727	4226	6870	0.267	5
2012	23360	3977	5617	0.240	5

Journal of the National Cancer Institute

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	5976	386	866	0.145	4
1993	7679	466	1161	0.151	4
1994	6945	541	1172	0.169	4
1995	6483	476	1007	0.155	4

1996	6986	438	1065	0.152	4
1997	7781	617	1026	0.132	4
1998	7451	436	1021	0.137	4
1999	9424	661	1313	0.139	4
2000	8730	578	1439	0.165	4
2001	7888	580	1020	0.129	5
2002	7558	502	842	0.111	5
2003	7678	529	877	0.114	5
2004	7459	555	1054	0.141	5
2005	7069	527	903	0.128	5
2006	7171	396	879	0.123	5
2007	6239	464	786	0.126	5
2008	6346	400	636	0.100	5
2009	5995	359	542	0.090	5
2010	6287	372	672	0.107	5
2011	6520	310	692	0.106	5
2012	4741	228	462	0.097	5

Lancet

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	17735	2614	1673	0.094	3
1993	16980	2437	1750	0.103	3
1994	16924	2392	1525	0.090	3
1995	15848	2110	1365	0.086	3
1996	16238	2558	1238	0.076	3
1997	19403	2549	1565	0.081	3
1998	19294	2593	1646	0.085	3
1999	20352	2639	1797	0.088	4
2000	17515	2210	1612	0.092	4
2001	17046	2212	1482	0.087	4
2002	19134	2149	1623	0.085	4
2003	22174	2111	1583	0.071	4
2004	21153	1785	1422	0.067	4
2005	20026	1651	1422	0.071	4
2006	20725	1730	1110	0.054	4
2007	23483	1852	1537	0.065	4
2008	19404	1719	1630	0.084	4
2009	19173	1497	1344	0.070	4
2010	18130	1689	1476	0.081	4
2011	18866	1783	1449	0.077	4
2012	22419	1793	1661	0.074	4

Nature

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	30289	4110	5783	0.191	4

1993	29756	3603	5510	0.185	4
1994	27149	3414	5046	0.186	4
1995	28094	3379	4429	0.158	3
1996	27319	3148	4198	0.154	4
1997	27920	3168	4408	0.158	4
1998	28768	3112	4382	0.152	4
1999	27159	2855	3857	0.142	4
2000	32966	3321	4328	0.131	4
2001	32088	3089	4473	0.139	4
2002	30279	3019	4160	0.137	4
2003	28049	2838	3686	0.131	4
2004	28292	2917	3652	0.129	4
2005	31893	3155	3916	0.123	4
2006	31105	3355	4321	0.139	4
2007	30179	2990	4047	0.134	5
2008	31998	3159	4391	0.137	5
2009	32416	3309	5001	0.154	5
2010	32133	3124	4940	0.154	5
2011	32069	3096	4971	0.155	5
2012	32787	3194	5156	0.157	5

New England Journal of Medicine

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	17138	1767	1881	0.110	4
1993	18572	1785	1977	0.106	4
1994	17487	1735	1694	0.097	4
1995	17118	1625	1801	0.105	4
1996	16245	1639	1699	0.105	4
1997	15770	1617	1654	0.105	4
1998	15719	1478	1336	0.085	5
1999	16487	1565	1417	0.086	5
2000	15488	1502	1476	0.095	4
2001	16184	1511	1467	0.091	5
2002	15026	1506	1437	0.096	5
2003	17181	1734	1481	0.086	4
2004	16318	1674	1444	0.088	4
2005	15508	1534	1435	0.093	4
2006	14332	1488	1257	0.088	4
2007	15873	1616	1434	0.090	4
2008	16550	1530	1493	0.090	4
2009	15823	1438	1359	0.086	4
2010	14992	1473	1227	0.082	4
2011	15602	1550	1307	0.084	5
2012	14801	1663	1258	0.085	5

Ophthalmology

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	5950	782	1015	0.171	7
1993	7178	994	1311	0.183	7
1994	6331	858	1297	0.205	7
1995	6683	1026	1467	0.220	7
1996	9179	1503	1733	0.189	9
1997	7861	1277	1852	0.236	7
1998	8863	1432	1914	0.216	7
1999	9234	1395	2267	0.246	7
2000	8719	1361	1883	0.216	7
2001	8851	1467	1966	0.222	7
2002	9210	1443	2052	0.223	8
2003	9534	1550	2241	0.235	7
2004	9312	1433	2131	0.229	7
2005	9367	1402	2197	0.235	7
2006	9890	1621	2481	0.251	7
2007	9829	1562	2592	0.264	7
2008	10416	1584	2594	0.249	7
2009	10382	1617	2543	0.245	6
2010	10545	1602	2602	0.247	7
2011	10970	1866	2852	0.260	7
2012	11186	1756	2551	0.228	7

Science

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	33424	2455	5135	0.154	3
1993	35525	2822	5709	0.161	4
1994	34692	2670	5343	0.154	4
1995	35433	2880	5439	0.154	4
1996	37300	2921	5587	0.150	4
1997	35692	2731	5171	0.145	4
1998	33961	2768	4709	0.139	4
1999	33434	2602	4546	0.136	4
2000	29436	2350	3842	0.131	4
2001	27901	2344	3435	0.123	4
2002	30331	2459	3464	0.114	4
2003	25921	2240	3024	0.117	4
2004	25827	2308	2492	0.096	4
2005	26377	2354	2553	0.097	4
2006	24885	2199	2502	0.101	5
2007	24439	2223	2339	0.096	4
2008	24003	2191	2461	0.103	5
2009	25245	2346	2249	0.089	5
2010	25401	2143	2234	0.088	5
2011	25966	2159	2108	0.081	5

2012	25793	2173	2226	0.086	5

The Journal of the American Medical Association

Year	References	Self-citations	Re-citations	TFF	Median cited halflife
1992	16383	1672	1889	0.115	4
1993	15229	1679	1785	0.117	4
1994	14988	1746	2011	0.134	4
1995	15464	1777	1943	0.126	4
1996	15290	1557	1766	0.116	4
1997	17411	1748	1772	0.102	4
1998	15720	1725	1863	0.119	4
1999	14951	1553	1817	0.122	4
2000	14770	1485	1855	0.126	4
2001	16079	1388	1691	0.105	4
2002	18069	1669	2108	0.117	5
2003	17338	1698	2314	0.133	4
2004	14948	1346	1871	0.125	5
2005	15857	1255	1660	0.105	5
2006	13982	1241	1648	0.118	4
2007	13190	1035	1440	0.109	5
2008	12960	908	1089	0.084	5
2009	12215	1049	1112	0.091	5
2010	10600	913	1097	0.103	5
2011	10321	791	992	0.096	5
2012	11298	845	991	0.088	5