On Evaluation Of Faculty Research Impact Of Citation Analysis

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Abstract

Citation analysis is gaining importance in evaluation of faculty research because of the need for objective, consistent analysis and because of the availability of databases that provide citation information. An overview of citation analysis is presented, along with criteria for and examples of manual and electronic citation analysis. The example of the manual count determines the average number of bibliographic citations per article; the recency of the citation; the author self-citation rate; the percentage of citations listed in the articles from books, journals, or other publications; the average number of pages per article; the incidence of citations to the journal in which the article is published (journal self-citations). The examples of the electronic count give number of citations from authors in other journals, impact factor, immediacy index, and cited half-life. Results provide insight into availability of data and possible uses of that data; i.e., faculty and research evaluation, selection of journals in which to publish, and implications for the future.

Introduction

With many business journals on the market, it is difficult at times to know which journal is best, which represents the highest standards for research in the field. Faculty are evaluated in their research efforts, and the question arises regarding how to evaluate when journals may not be equal in quality. A citation analysis provides some basis for evaluation. The purposes of citation analysis are many and varied. According to Starbuck and Mezias (1997), "citation rates measure visibility. Journals with larger circulations tend to receive more citations. American journals tend to get more citations than foreign ones, especially ones in foreign languages." One "may distinguish three application areas of citation analysis: the evaluation of scientists, publications,. and scientific institutions; the investigation of hypotheses concerning the history and sociology of science and technology; and the study of the performance characteristics of the information search and retrieval procedures" (Peritz, 1992). Peritz also suggests that merely counting number of citations is not enough. He says that the average number of citations needs to be compared with other papers dealing with like subjects or with other journals. Additional areas that he identified as pertinent in citation analysis were such classifications as material type and date of publication.

One of the easiest methods of citation analysis is the citation count; that is, "determining how many citations have been received by a given document or set of documents over a pe-

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riod of time.... This measure allows one to compare the impact of journals that publish different numbers of articles" (Smith, 1981). Peritz has noted that "citations can be viewed as legitimate objects of research, and, in fact, citation analysis has often proven itself to be a meaningful research tool..." (Peritz, 1992).

Related Research

A citation analysis of the *Journal of Consumer Research* identified five types of reference sources that were listed in articles appearing in that journal (Leong1989). These references include books, academic journals, conference proceedings, unpublished materials, and other publications. The study revealed trends for that discipline. It found that 53 percent of the articles' citations were to academic journals and 31 percent were to books. The remainder of the percentages was to other identified types of publications. Leong concluded that the *Journal of Consumer Research* displayed a trend toward the increasing use of academic journal references by *Journal of Consumer Research* scholars. "The relative use of journal articles and conference proceedings as the major sources of citations generally has increased over the period of time studied" (Leong 1989). He also noted that there appeared to be a trend away from citing from books. He concluded that the trend away from books was consistent with findings by other researchers that, in general, the use of the book has "shown a general decline in its importance as a communication vehicle in most fields, particularly the natural sciences . . . although much less so in the humanities" (Goldman 1979; Leong 1989).

In their study, Holsapple, Johnson, Manakyan, and Tanner (1993) discovered that for the years 1987-1991 (while examining 27,543 citations from business computing research journals) 53.7 percent of the citations were to journal articles, 34.8 percent were book citations, and 11.5 percent were citations to proceedings.

Williams, Triche, and Ross (1994) conducted a study to determine the scientific status of the *Journal of Business Communication*, specifically to determine whether the *Journal* is a hard-science, research-based discipline. They found that the *Journal of Business Communication* is not yet a hard-science, research-based journal, but evidence supports the conclusion that it is moving in the direction of becoming a hard-science, research-based discipline.

Information for citation analysis also can be obtained from electronic data sources. The Institute for Scientific Information (ISI) publishes the *Journal Citation Reports* (JCR), which provides a systematic and objective means of determining the relative importance of science and social sciences journals within their subject categories. Citation data offer a unique view of primary research journals, one that is objective and quantifiable. *Journal Citation Reports* is available in two versions--science edition and social sciences edition. The science edition provides citation data on nearly 5,000 leading science journals. It is compiled from the complete Institute for Scientific Information database that includes topics from Agriculture to Zoology. The social sciences edition provides citation data on approximately 1,700 leading social sciences journals. It is compiled from the complete Institute for Scientific Information database that includes topics from anthropology to women's studies. The editions are published annually. Subscription, usually purchased by libraries, includes access to one annual issue covering the prior year's data. The editions are available on CD-ROM, Microfiche, and on the Worldwide Web (*Journal Citation Reports*, 1999).

Statement of the Problem

There is a need for evaluation of research publications for many reasons. First, writers need to know which journals are hard-science, research-based journals and which are soft-science, non-research-based journals when writing for and submitting to journals for publica-

tion. They need to know which journals are having the greatest impact in their fields. Second, merit evaluations of faculty necessitate a knowledge of quality of publications, and the question ultimately arises regarding how to evaluate when journals may not be equal in quality. Third, faculty, when writing articles for publication, need guidance regarding citation of other research. For these reasons, manual citation analysis can be conducted to determine

1. What is the average number of bibliographic citations per article?
2. What is the recency of the citation? Within the last five years of the publication date of the article?
3. What is the author self-citation rate?
4. What percentage of citations listed in the articles are from books, journals, or other publications?
5. What is the average number of pages per article?
6. What is the incidence of citations to the journal in which the article is published (journal self-citations)?

An electronic citation analysis can be conducted to determine

7. What is the total number of cites a journal is receiving?
8. How often are the articles from these journals being cited by authors in other journals--impact factor?
9. How soon after publication are articles being cited--immediacy index?
10. How long are journal articles being used--cited half-life?

Methodology

To conduct a manual citation analysis one must first select a journal to be analyzed. If the chosen journal will also be used in a search of an electronic database, then one must determine if that journal is listed in the database; i.e., is it listed in the *Journal of Citation Reports* (JCR), the *Science Citation Index* (SCI), or the *Social Sciences Citation Index* (SSCI).

A manual count can be conducted using a citation analysis form (See Appendix). Ground rules need to be established, such as whether to use only full-length articles, and not use news items, brief notes, letters, responses, and book reviews. The data collection form (See Appendix) was designed for recording all information relative to citations. This instrument was field-tested using selected individuals who provided feedback relative to the practicality, usability, and validity of the form. Information provided was then used in the final design of the instrument (William, Triche, and Ross 1994).

An electronic search can be conducted using *Journal Citation Reports* to determine total citations, impact factor, immediacy index, and the cited half-life.

Analysis of Data

The data can be analyzed using frequencies and percentages. Both the manual count and the electronic count can provide valuable information, although the electronic data is more readily available and is much less time consuming.

Manual Citation Analysis

The manual count using the Citation Analysis Data Form shown in the Appendix provides the following information: number of citations per article; recency of citations; author self-citations; citations from journals, books or other publications; average number of pages; and journal self-citations. A review of literature was conducted to establish criteria.

Number of Citations Per Article

Price (1970) states that the average number of bibliographic citations listed in articles classified as hard-science, research-based disciplines is 22. However, MacRoberts and MacRoberts

(1989) point out that many of the hard-science, research-based disciplines' average citation rate varies significantly. For example, the citation rate averages range from a low of 5 to 6 in engineering, mathematical, and technology-oriented disciplines; 8 to 10 in biology and psychology; 12 to 15 in chemistry, clinical medicine, earth science, physics and space science; and the average is around 20 in the biomedical field.

Starbuck and Mezias (1997) state that citation rates incorporate systematic biases arising from the bibliographic practices in different fields; i.e., articles in applied psychology or management cite around 23 references on the average. Articles in educational or social psychology cite around 29 references each, and in the general psychology category around 35 references each.

The Price criterion of 22 bibliographical citations per article is recommended for use in a manual count citation analysis.

Recency of Citations

For hard-science, researched-based disciplines, Price's Index (1970) indicates that, on the average, 43 percent of the cited research is derived from research from within the last five years of the publication date of the article. The 43 percent, last five-year measurement is recommended for use in citation analysis.

Author Self-Citation

Garfield and Sher (1963) found that authors working in research-based disciplines tend to cite themselves on the average of 20 percent of the time. However, MacRoberts and MacRoberts (1989) claim approximately 10 percent to 30 percent of all the citations listed fall into the category of author self-citation. Additionally, MacRoberts and MacRoberts conclude that "very few articles do not include any self-citations, that the distribution of the number of self-citations per article has a wide range and that authors are inclined to cite their own work more abundantly that the work of any single author."

The Garfield and Sher 20 percent author self-citation rate is recommended.

Citations from Journals, Books, or Other Publications

Leong's (1989) citation analysis of the *Journal of Consumer Research* revealed that 53 percent of the articles' citations were to academic journals and 31 percent were to books. The remainder of the percentages was to other types of publications. He concluded that there seemed to be a trend away from citing from books. That conclusion was consistent with findings by other researchers that, in general, the use of the book has "shown a general decline in its importance as a communication vehicle in most fields, particularly the natural sciences . . . although much less so in the humanities" (Leong 1989; Goldman 1979). In their study, Holsapple, Johnson, Manakyan, and Tanner (1993) discovered that for the years 1987-1991 (while examining 27,543 citations from business computing research journals) 54 percent of the citations were to journal articles, 34 percent were book citations, and 12 percent were citations to other publications.

The Hopsapple, et al, study criteria is recommended for use in the manual count citation analysis.

Average Number of Pages

Garfield and Sher (1963) studied average page lengths for scientific journals. They found that for scientific literature, the average page length was 5.4 pages per article. Cline (1978), in a study of library science literature, found slightly different averages for that discipline. Her citation analysis of College and Research Libraries and Special Libraries disclosed an average of 5.62 pages per article for College and

Research Libraries and 4.14 pages per article for Special Libraries. However, when Cline analyzed the averages by decade, she found that the average page lengths were increasing. In the period 1970-1974, the College and Research Libraries had increased to an average of 7.66 pages per article, and Special Libraries had grown to an average of 5.27 pages per article. Dimond and Simonson (1984), in a study of three education journals, found that averages among theory, research-based education journals ranged from 12 pages in 1960s, 15 pages in the 1970s, and 14 pages in the mid-1980s.

The Dimond and Simonson criterion for the average page length of 14 is recommended.

Journal Self-Citation

Garfield and Sher (1963) noted that, on the average for scientific literature journals, the self-citation rate was an average of approximately 20 percent. Clines (1978) noted that by the mid-seventies, the journal self-citation rate for a portion of library science literature had risen to 35 percent.

The Garfield and Sher 20 percent as the average for journal self-citation is recommended. Table 1 summarizes the criteria recommended for the manual citation analysis.

Table 1
Recommended Criteria for Citation Analysis

	Criteria
Average No. of Citations per Article	22
Citations < 5 Yrs.	43%
Author Self-citation	20%
Citations to Journals	54%
Citations to Books	34%
Citations to Other Publications	12%
Average Pages per Article	14
Journal Self-citation	20%

Electronic Citation Analysis

A primary way of determining the value of the work in a discipline is by studying the impact of that discipline on other fields. An impact factor is the average number of citations received in one year by the articles that appeared during the two previous years.

Starbuck and Mezias (1997) analyzed results found in the *Social Science Index* and created a ranked list of journals of interest to business scholars, including psychological, sociological, and business journals. Starbuck's list contains 359 journals.

In their citation analysis of business computing systems journals that received more than 50 citations in the 1987-91 period, Holsapple, Johnson, Manakyan, and Tanner (1994), developed a list of 41 journals.

The *Journal Citations Reports* database shows a varying number of journals for each year (*Journal Citation Reports*, Science Edition 1997). This report is published annually and provides valuable information on activity. The *Report* for 1998 data will be published in the fall of 1999.

Journal Citation Reports (JCR) Science Edition and Social Science Edition were used to demonstrate the type of data that can be retrieved. Information shown in Table 2 from the *Journal Citation Reports* includes the following data fields with sort and filter options:

1. *Total Cites* indicates the total number of times that each journal as been cited in a given year.
2. *Impact Factor* measures the frequency with which the average article in a journal has been cited in a particular year. The impact factor helps evaluate a journal's relative importance, especially when compared to others in the same field. The impact factor is calculated by dividing the number of cur-

Table 2
Journal Citation Reports
1997 Science Edition
Filtered by "Computer Science, Information Systems"
Sorted on Journal Abbreviation

Journal Abbreviation	ISBN	1997 Total Cites	Impact Factor	Immed. Index	Cited Half-Life
Acm T Database Syst	0362-5915	621	0.423	.200	>10.0
Acm T Inform Syst	1046-8188	286	0.781	.143	7.6
Acta Inform	0001-5903	350	0.275	.095	>10.0
Annu Rev Inform Sci	0066-4200	133	1.000		8.3
Aslib Proc	0001-253X	45	0.206	.000	
Bell Labs Tech J	1089-7089	26	0.840	.093	
Comput Commun	0140-3664	146	0.182	.000	4.6
Comput J	0010-4620	1277	0.250	.038	>10.0
Comput Networks Isdn	0169-7552	416	0.329	.045	5.1
Comput Secur	0167-4048	17	0.075	.000	
Data Base Adv Inf Sy	0095-0033	95	0.233		
Data Knowl Eng	0169-023X	41	0.000	.000	
Decis Support Syst	0167-9236	213	0.264	.000	4.0
Distrib Parallel Dat	0926-8782	36	0.519	.000	
Eur J Inform Syst	0960-085X	27	0.581	.000	
Ibm Syst J	0018-8670	257	0.480	.839	6.0
Ieee Acm T Network	1063-6692	467	1.093	.102	3.4
Ieee Multimedia	1070-986X	148	1.111	.067	3.0
Ieee Network	0890-8044	245	1.288	.132	4.0
Ieee T Knowl Data En	1041-4347	525	0.465	.064	4.8
Ieice T Fund Electr	0916-8508	212	0.189	.039	3.1
Ieice T Inf Syst	0916-8532	3	0.003	.000	
Inform Comput	0890-5401	1586	0.636	.020	>10.0
Inform Manage	0019-9966	508	0.697	.024	6.1
Inform Process Lett	0020-0190	1051	0.249	.015	7.4
Inform Process Manag	0306-4573	367	0.578	.000	5.9
Inform Sci-Appl	1069-0115	8	0.158		
Inform Sciences	0020-0255	541	0.174	.029	>10.0
Inform Software Tech	0950-5849	156	0.275	.053	4.4
Inform Syst	0306-4379	603	1.258	.158	6.0
Inform Technol Libr	0730-9295	47	0.193	.000	
Int J Coop Inf Syst	0218-8430	9	0.242	.071	
Int J Med Inform	1386-5056	5		.094	
Internet Res	1066-2243	45	0.356	.023	
J Acm	0004-5411	2179	1.355	.143	>10.0
Jam Med Inform Assn	1067-5027	293	2.164	.444	2.5
J Am Soc Inform Sci	0002-9231	903	1.260	.213	6.4
J Chem Inf Comp Sci	0095-2338	1929	2.073	.220	4.0
J Inform Sci	0165-5515	197	0.427	.154	5.9
J Inform Technol	0268-3962	82	0.537	.130	

J Strategic Inf Syst	0963-8687	26	0.765	.000	
J Vis Commun Imag R	1047-3203	99	0.344	.043	
J Visi Signal Proc	0922-5773	101	0.265	.040	4.0
Libr Software Rev	0742-5759	12	0.286	.000	
Med Inform	0307-7640	194	0.982	.842	4.0
Mis Quart	0276-7783	1091	1.620	.267	8.8
Multimedia Syst	092-4962	57	0.915	.000	
Online Cdrom Rev	1353-2642	28	0.147	.069	
P Asis Annu Meet	0044-7870	37	0.000	.000	
Prog-Electron Lib	0033-0337	59	0.393	.217	
Rairo-Inf Theor Appl	0988-3754	94	0.269	.000	
Wirtschaftsinf	0937-6429	61	0.270	.111	

rent citations to articles published in the two previous years by the total number of articles published in the two previous years; for example, the formula for the impact factor for a journal published in 1997 is calculated as follows:

Cites in 1997 to articles published in
1995 = 80
1996 = 20
95+96= 100
Number of articles published in
1995 = 20
1996 = 22
95+96 = 44

Calculation of Impact Factor

$$\frac{\textit{Cites to recent articles}}{\textit{Number of recent articles}} = \frac{100}{44} = 2.27$$

3. *Immediacy Index* is a measure of how quickly the average article in a specific journal is cited.

Cites in 1997 to articles published in the same year. 1997 = 4
Number of articles published in 1997 = 15

Calculation

$$\frac{\textit{Cites to current articles}}{\textit{Number of current articles}} = \frac{4}{15} = 0.267$$

4. *Cited Half-Life* reflects the ongoing use of a particular journal. It is the number of publication years from the current year which accounts for 50 percent of current citations received. This figure helps evaluate the age of the majority of cited articles published in a journal. Only those journals cited 100 times or more have a cited half-life published *in Journal Citation Reports*. The cited half-life for a historical article would be expected to be greater than that for an article on technology that is constantly changing.

Journal Citation Reports was used for the years 1994 to 1997 to compare the number of journal on the list, using journals in the category of "Computer Science, Information Systems." The number of journals on the list varied. The 1997 report listed 52 journals; 1996, 49 journals; 1995, 43 journals and 1994, 43 journals. The journals listed in the Science Edition were aligned with "Computer Science; Information Systems"(Table 2); very few of these were listed in *Cabell's Directory of Publishing Opportunities in Management and Marketing*, 1997-98. On the other hand, the journals listed in the Social Science Edition were aligned with "Management" (See Table 3) and most were listed in *Cabell's*.

Journal Citation Reports also publishes information showing which journals are citing articles in a specific journal; i.e., *MIS Quarterly*.

Table 3
Journal Citation Reports
1997 Social Science Edition
Filtered by "Management"
Sorted on Journal Abbreviation

Journal Abbreviation	ISBN	1997 Total Cites	Impact Factor	Immed. Index	Cited Half-Life
Acad Manage J	0001-4273	3248	2.526	0.148	8.2
Acad Manage Rev	0363-7425	2790	2.643	0.727	9.3
Admin Sci Quart	0001-8392	3222	3.306	0.458	> 10.1
Adv Strateg Manage	0742-3322	65	0.200		
Calif Manage Rev	0008-1256	687	1.158	0.179	8.5
Can J Adm Sci	0825-0383	38	0.057	0.065	
Decision Sci	0011-7315	894	0.586	0.000	8.6
Group Decis Negot	0926-2644	48	0.164	0.125	
Group Organ Manage	1059-6011	274	0.477	0.000	8.4
Harvard Bus Rev	0017-8012	2988	2.463	0.365	8.3
Hum Relat	0018-7267	1425	0.538	0.032	> 10.0
Hum Resour Manage R	1053-4822	13	0.143	0.000	
Hum Resource Manage	0090-4848	536	1.698	0.114	4.9
Ieee T Eng Manage	0018-9391	370	0.635	0.056	8.2
Ind Market Manage	0019-8501	478	0.355	0.021	9.7
Inform Manage	0019-9966	508	0.697	0.024	6.1
Int J Forcasting	0169-2070	299	0.493	0.049	5.8
Int J Manpower	0143-7720	20	0.045	0.000	
Int J Oper Prod Man	0144-3577	303	0.359	0.014	4.9
Int J Select Assess	0965-075X	46	0.232	0.500	
Int J Serv Ind Manag	0956-4233	46	0.381	0.000	
Int J Technol Manage	0267-5730	48	0.092	0.000	
Interfaces	0092-2102	583	0.525	0.044	8.1
J Econ Manage Strat	1058-6407	29	0.592	0.000	
J Forecasting	0277-6693	321	0.316	0.000	7.5
J Inform Technol	0268-3962	82	0.537	0.130	
J Int Bus Stud	0047-2506	686	0.793	0.043	8.0
J Manage	0149-2063	889	0.722	0.258	6.5
J Manage Inquiry	1056-4926	19	0.360	0.000	
J Manage Stud	0022-2380	691	0.662	0.200	7.8
J Oper Res Soc	0160-5682	1212	0.525	0.085	7.1
J Organ Behav Manage	0160-8061	104	0.077	0.000	> 10.0
J Organ Change Manag	0953-4814	75	0.145	0.036	
J Prod Innovat Manag	0737-6782	513	1.038	0.037	5.5
J Small Bus Manage	0047-2778	10	0.147	0.000	
Leadership Quart	1048-9843	148	1.239	0.000	4.2
Long Rang Plann	0024-6301	423	0.275	0.035	6.8
Manage Learn	1350-5076	43	0.378	0.000	
Manage Sci	****-****	5127	0.830	0.146	> 10.0
Mis Quart	0276-7783	1091	1.620	0.267	8.8

Table 3 (continued)
Journal Citation Reports
1997 Social Science Edition
Filtered by "Management"
Sorted on Journal Abbreviation

Journal Abbreviation	ISBN	1997 Total Cites	Impact Factor	Immed. Index	Cited Half-Life
Negotiation J	0748-4526	133	0.291	0.083	6.2
New Tech Work Employ	0268-1072	30	0.833	0.000	
Omega-Int J Manage S	0305-0483	357	0.280	0.000	7.5
Organ Behav Hum Dec	0749-5978	2244	0.995	0.000	>10.0
Organ Dyn	0090-2616	411	0.675	0.000	9.6
Organ Sci	1047-7039	332	0.622	0.025	4.0
Organ Stud	0170-8406	431	1.133	0.200	5.6
R & D Manage	0033-6807	256	0.449	0.038	5.9
Res Policy	0048-7333	704	0.946	0.026	7.8
Res Technol Manage	0895-6308	127	0.264	0.026	4.7
Rev Ind Org	0889-938X	78	0.289	0.156	
Serv Ind J	0264-2069	81	0.162	0.000	
Sloan Manage Rev	0019-848X	860	1.807	0.345	7.0
Strategic Manag J	0143-2095	2423	1.735	0.169	7.1
Syst Dynam Rev	0883-7066	105	0.906	0.588	3.6
Syst Practice	0894-9859	129	0.587	0.057	5.1
Total Qual Manage	0954-4127	9	0.076	0.000	
Tourism Manage	0261-5177	149	0.182	0.000	5.8
Workforce	0031-5745	4	*.***	0.016	

Table 4
Journal Citation Reports--1997 Science Edition
Partial List--13 of 69
Cited Journal Listing for Journal: *MIS Quarterly*

Impact	Citing Journal	All Yrs	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	Rest
	All Journals	1091	4	10	71	71	74	68	109	54	100	178	352
0.697	Inform Manage	154	0	2	11	8	5	6	23	8	12	24	55
*.***	J Comput Infor S	69	0	0	3	5	8	9	6	1	4	12	21
1.620	MIS Quart	60	4	1	5	6	4	2	4	4	7	7	16
*.***	Inform Syst Res	52	0	0	4	3	4	2	4	3	6	12	14
0.264	Decis Support Sys	48	0	0	2	1	3	1	2	3	5	9	22
0.765	J Strategic Inf S	47	0	0	1	1	3	3	10	0	5	7	17
0.581	Eur J Inform Syst	43	0	2	2	3	4	2	6	2	3	9	10
0.635	IEEE T Eng Manage	39	0	0	1	5	1	3	4	3	3	5	14
0.537	J Inform Tech	39	0	1	6	3	3	1	9	0	1	4	11
0.275	Inform Software T	37	0	0	4	4	6	5	2	1	4	4	7
0.280	Omega-Int J Manag	35	0	1	3	5	3	2	2	2	7	1	9
*.***	Int J Inform Manag	34	0	0	1	1	1	1	2	2	3	6	17

A partial list (the top 13 out of 69 citing journals) is provided in Table 4 to show the information format.

These reports and others like them provide valuable information to faculty who are evaluated on their publishing record, to administrators who must do the evaluating, and to the journals that are listed in the databases. One might wonder how journals get included in the database. Information can be found at the following website: http://www.isinet.com/hot/ essays/199701 .html. Journal evaluation and selection are conducted on an ongoing basis at the Institute for Scientific Information (ISI) with journals added to and deleted from the database as frequently as every two weeks. ISI's editorial staff reviews nearly 2,000 new journal titles annually, but only 10-12 percent of the journals evaluated are selected. Moreover, existing journal coverage in ISI is also constantly under review. Journals now covered are monitored to ensure that they are maintaining high standards and a clear relevance to the ISI products in which they are covered.Each journal goes through an extensive evaluation process before being selected or rejected. The ISI editors performing journal evaluations have educational backgrounds relevant to their areas of responsibility as well as experience and education in information science. Their knowledge of the literature of their field is extended by consultation with established networks of advisors who participate in the evaluation process when needed (Garfield, 1996).

It would appear that, in order to be comprehensive, an index to the journal literature of science might be expected to cover all scientific journals published. This approach would be not only impractical economically, but as analyses of the scientific literature have shown, unnecessary. It has been demonstrated that a relatively small number of journals publish the bulk of significant scientific results. This principle is often referred to as Bradford's Law (Garfield, 1979). In the mid-1930's, S. C. Bradford realized that the core literature for any given scientific discipline was composed of fewer than 1,000 journals. Of this 1,000 journals, there are relatively few with a very strong relevance to the given topic, whereas there are many with a weaker relevance to it. Those with a weak relevance to the given discipline or topic, however, typically have a strong relevance to another discipline. Thus, the core scientific literature can form itself around various topics, with individual journals becoming more or less relevant depending on the topic. Bradford understood that an essential core of journals forms the literature basis for all disciplines, and that, therefore, most of the important papers are published in relatively few journals (Garfield, 1979).

Recent citation analyses have shown that as few as 150 journals account for half of what is cited and one quarter of what is published. It has also been shown that a core of approximately 2,000 journals now account for about 85 percent of published articles and 95 percent of cited articles (Garfield, 1996). But this core is not static. Its basic composition changes constantly. The ISI editorial team's mission is to identify and evaluate promising new journals that will be useful to ISI subscribers, and to delete journals that have become less useful.

Many factors are taken into account when evaluating journals for coverage, ranging from qualitative to the quantitative. The journal's basic publishing standards, its editorial content, internationality of authorship, and the citation data associated with it are all considered. Garfield (1990), the founder of the Institute for Scientific Information, describes the factors very well.

Basic Journal Standards

Timeliness of publication is one of the most basic criteria in the evaluation process, and it is of primary importance (Garfield, 1990). ISI also notes whether or not the journal follows international editorial conventions, which optimize retrievability of source articles. These conventions

include informative journal titles, fully descriptive article titles and abstracts, complete bibliographic information for all cited references, and full address information for every author. Application to the peer review process is another indication of the journal's standards and indicates overall quality of the research presented and the completeness of cited references (Garfield, 1990).

Editorial Content

The true core of the scientific literature is embodied in a relatively small number of journals. However, scientific research continues to give rise to specialized fields of studies, and new journals emerge as published research on a new topic achieves critical mass. The ISI editor determines if the content of a new journal will enrich the database of if the topic is already adequately covered. The enormous amount of data at their fingertips, and their daily observation of virtually every new science journal published, position the ISI editorial team to spot emerging topics, and "hot fields" in the literature (Garfield, 1990).

Internationality

Geographic representation of a journal is another consideration. To meet the needs of its international subscriber base, ISI seeks to cover journals with international diversity among authors of both source articles and cited articles. To properly reflect the global context in which scientific research takes place, and provide balanced coverage in each category, ISI seeks to cover the best regional journals as well. However, rather than compare a regional journal with all journals in its particular category, the ISI editor considers it in terms of journals from the same geographic area. High journal publishing standards, especially timeliness, and English language bibliographic elements remain essential (Garfield, 1990).

Citation Analysis

The ISI evaluation process is unique in that the editors have a wealth of citation data at their disposal. The importance of correctly interpreting and understanding these data when evaluating journals cannot be emphasized too strongly. Because the number of authors and journals varies greatly among disciplines, discipline-specific citation levels and rates also vary greatly. Smaller fields like botany or mathematics do not generate as many articles or citations as do larger fields such as biotechnology or genetics. Likewise, in some areas, particularly in the arts and humanities, it may take a relatively long time, even several years for an article to attract a meaningful number of citations, whereas in other areas, such as the life sciences, it is not unusual for citations to peak after only a few years (Garfield, 1990).

Several types of citation data are used. For established journals, these include overall citation rate, impact factor, and immediacy index. For new journals, the editors examine the publishing record of the journal's authors and editorial board members, noting where their articles have been published and if their work has been cited. Also, because ISI captures all cited references from each of the 8,000 journals covered, citation information is available on covered journals, as well as those not covered but which have been cited by any of the 8,000 core journals (Garfield, 1990).

When evaluating research, this means of evaluation should be used along with other methods, such as peer review. Pitfalls that all should be aware of are citation biases (i.e., language barriers, criticisms of an article rather than agreement, courtesy citations, readership size for different fields of study). Also, these databases are electronic and errors could be made at the data-entry level, causing information to be incorrect. All involved with citation analysis should check periodically to ensure that the

content is correct. Journal editors, especially, should be aware of how and where data about their authors and articles appear and should monitor the information.

Conclusions

Results of the manual count provide the average number of bibliographic citations per article; the recency of the citation; the author self-citation rate; the percentage of citations listed in the articles from books, journals, or other publications; the average number of pages per article; and the incidence of citations to the journal in which the article is published (journal self-citations).

Information obtained from the *Journal Citation Reports* shows total cites, impact factor, immediacy index, and cited half-life. It is not recommended that *Journal Citation Reports* users depend solely on citation data in their journal evaluations. Citation data are not meant to replace informed peer review. Additionally, careful attention should be paid to the many conditions that can influence citation rates, such as language, journal history and format, publication schedule, and subject specialty. This caution is supported by Eugene Garfield (1998), the founder of the Institute for Scientific Information, who says, "Using journal impact factors as a surrogate for actual citation counts is to be avoided. We all know that there is considerable variation within a particular journal. However, this does not mean that the impact factor of the journal in which a person has published is irrelevant. Certainly there is some prestige accorded a scientist who manages to have his papers accepted in high impact journals."

In conclusion, citation analysis is an important factor in the evaluation of journals, articles, and authors. Careful monitoring of databases by all that are affected by them, along with other means of evaluation, should ensure more valid results. Additionally, there are many authors trying to publish, from many different universities of different sizes and levels of prestige, and relatively few journals on the lists. In order to be successful in the "publish or perish" world, authors should naturally try to publish in the journals with the highest impact in the field; but if that fails, authors should publish in good, refereed journals that may not be on the lists. Evaluators of faculty research also should be aware that competition is fierce, and they should conduct realistic, consistent peer reviews within their departments. Publishing is a challenge to all involved, and the availability of electronic citation data will have a great impact in the future since many universities are purchasing databases for faculty research evaluation.

Suggestions for Future Research

Since citation analysis is such an important component in the journal evaluation process, continued research into each field of study is needed. Areas of study could also be compared to determine differences. Additionally, studies could be conducted to determine the most prolific authors publishing in the top journals in each field. Opportunities for research in citation analysis are unlimited. 🕮

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Appendix

Citation Analysis Form			
Journal Name Issue # Vol. # Date			
Article Title			
Article Subject			
Primary Author Name			
# Secondary Authors			
Name Sec. Author 1			
Name Sec. Author 2			
Name Sec. Author 3			
# Pages	# Citations	# <= 5 Yrs.	# > 5 Yrs
# Author Self Cites.		# <= 5 Yrs	# > 5 Yrs.
# Journal Self Cites		# <= 5 Yrs	# > 5 Yrs.
# Book Cites	# Journal Cites	# Other Cites	