Can electronic journal usage data replace citation data as a measure of journal use? An empirical examination[1]

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Abstract

Citation and print journal use data have been used to measure quality and usefulness of library journal titles. This study examined relationships among different measurements and found that electronic usage correlates with print usage and local citation data are a valid reflection of total journal usage but Impact Factors are not as valid.

Introduction

For many years, librarians and information scientists have struggled with how to best determine the value of a journal, either in the context of a library collection or a field of study. Libraries have developed a use-based measure, in the form of print re-shelving data or circulation data (if serials circulate), as one means of helping determine the value of a journal in their specific library collection. In contrast, citation measurement was developed by information scientists to give a

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broader, more research-based view of a journal's impact on a field of study. Citation data are tracked, compiled and sold by the Institute for Scientific Information (ISI). The best known product of ISI is probably the *Web of Knowledge* databases. ISI citation data can be divided into two groups (and, correspondingly, two products):

a. **Global citation data** – data are gathered by tracking the citation and publishing patterns of researchers throughout the world. An example of this kind of data is that found in Journal Citation Reports (JCR), and a specific global citation measure is that of the impact factor. Impact factors are a measurement of how often a journal is cited in the literature. The impact factor for journal X in 2000 is calculated by taking all the citations to journal X in 1998 and 1999, and dividing that by the total number of articles published in those two years. Another measure of global citation is "total citations" to a journal in a particular year. However, a journal title that publishes many articles per issue, or many issues in a year, will likely have a higher total citation count than a journal that is published less frequently, or contains less articles; the impact factor helps reduce that bias. Note that not all journals are indexed by ISI and only citations in ISI indexed journals are counted in calculating impact factors.

b. **Local citation data** – these citation data are local to a specific institution. For example, the Journal of X was cited 10 times in 1998 by the faculty at University of Y. Such data can be obtained, for a fee, through Local Journal Utilization Reports (LJUR), a product offered through ISI. It can also be collected locally by searching citation databases in the field(s) of interest. Note that this is a count of total citations from researchers at institution X and does not include any kind of attempt to normalize across journal titles according to how many articles are published in a certain journal.

Both print re-shelving data and citation data have been criticized for not providing a complete picture of journal use or value. Print re-shelving studies are expensive, time consuming, and not always accurate[1]. For example, users may re-shelve journals on their own; it is also difficult to determine how much use was made of a volume – the user may have glanced quickly at it or may have photocopied three articles. Both types of use will get equal weight in most re-shelving

studies. In addition, print re-shelving studies are only of use for determining the usefulness of a journal in a single library, and cannot necessarily be extrapolated to make generalities about how important a journal is to an entire institution, as individuals at the institution may have their own subscriptions and might not use the library copy.

Citation data, although generally viewed as useful for evaluating research performance and, to a certain degree, journal impact within a field of study, are also controversial [2,3,4]. The controversy partially stems from questions surrounding what motivates citation[5] and also because these data are not very timely in terms of providing feedback about what journals are currently cited. Also, citation data do not reflect use by those who do not publish; in an academic environment, this can include undergraduate and graduate students (a large and important user group for academic libraries), as well as staff and other users. The most widely used rank based on citation data, impact factors, are universal and not specific to individual institutions with individual research/teaching missions. However, impact factors are widely considered a useful tool for collection development because they offer librarians a broader view of what journals are most useful in a particular field. This can be especially helpful if a library does not have a particular title in its collection (and thus cannot obtain usage data) and wants to evaluate how useful it might be to researchers whom the library serves. In contrast, local citation data reflect citation activity at a particular institution. However, the local citation data produced by ISI must usually be paid for, which can make it inaccessible to some libraries. If the same citation data are gathered manually, the process can be time consuming.

Previous studies have shown that global citation measures such as journal impact factor do not correlate significantly with use of print journals in individual libraries[6,7]. However, Stankus and Rice found that when journals were grouped by subject, scope and language, there was a significant correlation between journal impact factor and use of print journals[8]. This was also the finding of Tsay, who found a correlation between frequency of use and impact factor for titles that publish clinical medicine and/or life sciences articles[9]; Tsay also found a significant correlation between frequency of use and worldwide citation frequency (as reported in Journal Citation Reports). Other studies looking at the relationship between the two have been somewhat inconclusive[10,11,12].

Studies have also been conducted to determine whether data on local citation and publication patterns in certain journals correlate with a library's own measures of in-house use. Blecic found correlations between the following three measures: in-house use (using re-shelving data collected for one day a week from October 1992 to January 1994), circulation, and citation by faculty (obtained through ISI's Local Journal Utilization Reports), at the University of Illinois at Chicago's Library of the Health Sciences[13]. Pearson and Spearman correlations between all the sets of data were statistically significant ($P<.0001$). However, locally collected (not from ISI) citation data for Indian space technology researchers did not correlate significantly well with library journal use[14].

With the emergence of electronic journals there comes a new ability to track use of electronic journals for which the library holds a subscription. For example, it was shown that use of paper and electronic journal titles in an academic health sciences library correlate significantly ($R=0.66$, $p<0.01$)[15]; it was also found that the use of print and electronic journal titles correlates

significantly for three vendors studied ($p<0.01$) with the titles' impact factors. However, researchers in the study did not examine whether the use correlates with local citation data which may be a more meaningful measure of journal's local impact[16]. In a 2003 study[17] of the Web-based NASA Astrophysics Data System, researchers found that the number of citations to articles followed the number of online article reads very closely, thus proving the "normative theory of citing"[18] that "the number of times a document is cited … reflects how much it has been used"[19]. Kurtz et al. rightly point to the need for further research in this new area of electronic journal use. They "expect the similarities and differences of reads and citations to become a central facet of bibliometric research … the combination of the two measures of use substantially improves the capabilities of bibliometric measurement"[20].

Such studies are of interest not only to librarians and information scientists, but also to researchers in other fields such as computer science and those studying the Web's role in scientific and/or scholarly communication. In recent correspondence to Nature, for example, Jon Kleinberg asked the question "how closely related are they [usage-based measures of impact] to traditional citation-based measures? We expect that there will be a rough correspondence between citation and usage in an aggregate sense … However, there will clearly be deviations from this general principle"[21].

Building on these previous findings, this study aims to investigate whether citation data are a valid measure of journal use by examining the relationship among various measures of a journal's value. An earlier version of the paper reporting preliminary results of the study was presented at the 10th International Conference of the International Society for Scientometrics and Informetrics[22]. The emphasis of the study is on (1) the relatively new electronic journal usage

data where little research of this kind has been done; and (2) local citation data which are theoretically a better measurement of local use than the more global impact factor. Specifically, the following research questions will be addressed:

1. Do new electronic usage measures correlate with the more established print usage measure of re-shelving data?
2. Do citation data (local and global) correlate with electronic journal usage data?
3. Is local citation data a better measure of journal use than the global journal impact factor?

Methodology

Data for all the variables listed below were collected at Concordia University Libraries. Concordia is a major Canadian university with an enrollment of over 31,000 students, and it has two campuses, both of which have a library. Print subscriptions are rarely duplicated between the two libraries, but electronic access to all journals is available whether on campus (at either library) or off campus, to faculty, staff and students.

Different disciplines have very different citation patterns and journal usage patterns. To ensure a valid examination of different variables and the compatibility of data, the study needs to be focused on a particular discipline. Journal titles from the subject areas of chemistry and biochemistry were used for the study and the details of data collection are described below.

Print re-shelving data

Print usage data were gathered through shelving studies. A total of 20 print journal titles from two different publishers were used: 11 from the American Chemical Society and 9 from the Royal Society of Chemistry. Titles used were those that Concordia Libraries had a current print subscription to at the start of the data collection period (June 2000), and for which continuous electronic usage data were available. Shelving staff in the Periodicals and Media Unit of both Concordia libraries collect data each time a bound volume or a loose issue of a journal is shelved. The data were reported for a full year only (usually the fiscal year, June 1 to May 31 of the following year). However, due to a transfer of certain volumes between libraries mid-year, some monthly statistics were available, thus enabling us to better match the time period of electronic usage data gathered (October 2000 to September 2003). Print shelving data were gathered for the period of June 2000 to September 2003.

Electronic journal usage data

All electronic journals used in this study are accessed only via publisher websites – these journals are not part of a large aggregator full text database, but are rather made available online directly through the publisher and as such are fully browsable and contain all text and images. Electronic usage data for the journals were collected via the electronic journal publisher's password-protected web site. Concordia does not collect electronic journal usage data through local library servers so the data collected from the publisher's web site were used.

For research question 1, data were gathered from two vendors: the American Chemical Society and the Royal Society of Chemistry. For research question 2, data from the American Chemical Society, Royal Society of Chemistry, Elsevier, and Wiley were used for all journals in the areas of chemistry and biochemistry, as determined by ISI. For all vendors, the data collected were the total number of HTML and PDF fulltext articles requested. This type of measure must be reported in Project COUNTER'S Journal Report 1 for a vendor to be considered Level 1 COUNTER compliant. Also, according to Shim et al. these numbers "provide a circulation count for electronic contents in a way analogous to the tradition circulation of books" [23], with the difference that these counts are obtained at an article level rather than a whole journal level.

Time periods of data collection varied according to what research question was being examined. For question 1, electronic journal usage data were gathered for the period of October 2000 to September 2003. For question 2, data were gathered for different time periods according to different electronic journal packages (as these packages were acquired by Concordia at different times). However, it is worth noting that although these are usage data for the most recent few years, during this time period, users may have been accessing journal articles that are, in some cases, over 100 years old. Ranked lists of the most popular electronic journals were compared with ranked lists of the most popular journal titles for citation by faculty at Concordia. See Table 1 for a list of the publishers, how many titles were used from each package, and the time period for which data were collected. For some titles, there is missing usage data for a journal, probably due to a flaw in the vendor's reporting system or because a title changed vendors/publishers. Titles with any missing data were excluded from the study.

Table 1: Summary of Electronic Journal Usage Data

Publisher	**Number of Titles**	**Time Period for E-journal Usage data**
American Chemical Society	16	October 2000 to June 2005
Elsevier	77	January 2003-June 2005
Wiley	19	January 2003-June 2005

Citation data

Two kinds of ISI citation-based data were used in this study. Journal Citation Reports (JCR), which contain journal impact factors, were obtained for the year 2001 (Concordia Libraries had only paid for that year's worth of data). Library Journal Utilization Reports (LJUR) for Concordia University (science) were purchased from ISI. These reports give a measure of a) how many times researchers from Concordia published in each journal, and b) how often researchers at Concordia cited each journal in the study. The Reports were purchased for the years 1981-2002, however, in all parts of the study, only LJUR data from 1998-2002 were used to roughly match the time frames of other data collected for the study, yet still provide enough citation data.

For research questions 2 and 3, journal titles in the following ISI subject categories (for both LJUR and JCR data sets) were used: biochemistry and biophysics; chemistry; chemistry and analysis; inorganic and nuclear chemistry; pharmacology/toxicology; physical chemistry/chemical physics. For all journals in these categories, the number of times the journal

had been cited by all researchers affiliated with Concordia (sum from 1998-2002, inclusive) was recorded.

Data Analysis

All sets of data were analyzed using SPSS software. Correlation analysis was used to address research questions. First, the data were examined to see if the frequency distributions of data sets were skewed. If the data sets were approximately normal, i.e. not overly skewed, the Pearson test for correlation was conducted to test for correlation; if data sets were badly skewed, the Spearman test for correlation was used. Data analyses were carried out for each vendor separately because different vendors may use different methods to record electronic usage data[24] and thus their usage data are not always completely comparable. In addition, for some parts of the study, the data collection times varied by vendor, because of different acquisition times for different vendors.

Findings

Electronic Usage Correlates with Print Usage

As seen in Table 2, significant correlations were found between electronic journal usage data and shelving data for print journal titles for both publishers. It should be noted that, because only a small number of titles in each package met the requirements for data collection (i.e., Concordia Libraries had a current print subscription to the title in June 2000, and there was sufficient electronic usage data available from the vendor), only a very small sample size was used for each

vendor. However, both correlation coefficients in Table 2 are very high, which provides assurance of the correlation found. The correlations suggest that the new electronic usage data can be used in place of the traditional re-shelving data, which are much more expensive to collect, and are becoming less relevant as more and more journals are available electronically.

Table 2: Correlation between print journal use and electronic journal use

Publisher	**N (number of journal titles used)**	**Number of print uses**	**Number of downloads**	**Pearson Correlation***
American Chemical Society	11	1763	15153	.766
Royal Society of Chemistry	9	179	2242	.876

*both correlations were significant at $P<0.01$

It is worth noting that current journals in the Royal Society of Chemistry package were available in both print and online formats at Concordia, whereas for the American Chemical Society journals, the current print subscriptions to all but one journal (Journal of the American Chemical Society) ended in 2001. The fact that there is still a correlation for the American Chemical Society titles suggests that print and electronic use measures correlate even when there are current subscriptions for the electronic versions, but only back issues for print titles.

Local Citation Data Correlate with Journal Usage Data

As seen in Table 3, for all three journal publishers, electronic journal usage data for Concordia correlate significantly with local citation data of Concordia researchers (as determined by Library Journal Utilization Reports, which are defined above).

Table 3: Pearson correlation values between local citation data and journal usage data, by vendor

Publisher	**N (number of journal titles used)**	**Local Cites**	**Number of Downloads**	**Correlation***
American Chemical Society	16	1094	35,041	0.935
Elsevier	77	1292	23,664	0.624
Wiley	19	114	3743	0.681

*all correlations were significant at $P<0.01$

No Correlation between Impact Factor and Journal Usage Data

Table 4 shows that the correlation between journal impact factors and electronic usage data are not significant for these three vendors. It can thus be concluded that there is no relationship between the journal impact factor and electronic usage data.

Table 4: Correlation between Impact Factor and Journal Usage Data

Publisher	**N (number of journal titles used)**	**Pearson or Spearman test**	**Correlation**	**Significance (p)**
American Chemical Society	16	Pearson	0.350	0.184
Elsevier	77	Spearman	0.131	0.255
Wiley	19	Spearman	0.237	0.328

Discussion and Conclusions

This study indicates that electronic usage data, as provided by most publishers of electronic journals, correlate significantly with print usage data in the areas of chemistry, biochemistry, and related fields. A similar correlation was found in a study of health science journals[25] (it should be noted that they used the same measure of electronic journal usage as in this study– the sum of HTML and PDF fulltext articles viewed). The results of the two studies suggest that, for electronic journals, vendor-supplied electronic journal usage data – in the form of PDF and HTML views - can replace the traditional and time-consuming way of determining library use of journals: print re-shelving studies.

The correlation indicates that the new electronic format does not appear to have had an effect on journal preferences among users – titles that were most read in print continue to be popular in the electronic format. It also indicates that some long-standing criticisms of print re-shelving studies (for example, that users can easily re-shelve journals on their own, and thus the use of that issue or volume would not be counted, or that such studies could not effectively count how many articles were looked at in a single volume or issue) have not affected the general accuracy of print re-shelving data in terms of providing a measure of the ranked popularity of journal titles. The results for the American Chemical Society journals also indicate that electronic journal usage data continue to correlate with print journal usage data even for print titles that are no longer currently subscribed to by the library.

Results from this study also indicate that local journal citation data significantly correlate with electronic journal usage. The correlation coefficients for Elsevier and Wiley, though significant, were not as high as for the American Chemical Society journals. However, it is worth noting that at the time of the study, Concordia had had access to the American Chemical Society for approximately 4 years, whereas access to the other two packages had only been in place for 1.5 years. This difference may have affected the strength of the correlations for Elsevier and Wiley titles, and more research should be conducted to see whether electronic journal packages take time to display "established" usage patterns. For example, some researchers may not know that the titles are available online and thus go elsewhere to find their articles.

This study also found that the global measure of journal impact factor did not correlate with electronic usage data. This finding agrees in principle with that of Davis who found that the most popular journals (as determined by examining where researchers from Cornell publish) did not match with the journals in those same subject areas with the highest impact factor. Davis concludes: "The generic metrics of the JCR simply cannot provide the campus-level data crucial to making informed decisions about the local importance of individual titles"[26]. However, the finding in this study is in contrast to that of Wulff and Nixon, who did find a significant correlation between print and electronic use of journals in an academic health sciences library, and their impact factors[27]. Others have also found a significant correlation between print use and journal impact factors[28,29], but none of these studies did a direct comparison of the correlation between usage and impact factors versus usage and local citation practices as our study did. It is also worth noting that both Wulff and Nixon and Tsay conducted studies in a medical setting, and the correlation between use and impact factor may vary between particular subject areas.

It may be that correlations between library journal use and impact factors were affected by the design of the study or that the correlation exists only for particular fields or at certain institutions. The results may also have been affected by researchers having their own personal subscriptions to high-impact journals in their areas of study, and they may consult these personal copies (either in print or online) rather than a library copy. In addition, the fact that these sets of data reflect use during different time periods (for example, downloads to Wiley articles were collected from 2003-2005, while the Journal Impact Factors for Wiley titles were for 2001; local cites to those journals were from 1998-2002, inclusive) may have an effect on the results. Within recent years, Concordia has hired a number of researchers in new fields and this could affect the use of a title significantly over a rather brief period.

Finally, impact factors are normalized according to the number of articles published in that journal during a specific time period, whereas the usage data have not been normalized in this way. Correlation analysis of the total number of citations per journal (taken from Journal Citation Reports) shows that these figures correlate significantly with electronic journal use for all three vendors. Further research is needed to reach a firmer conclusion on the impact of these issues. For example, the idea of "content adjusted usage"[30], which is a metric consisting of the number of full-text accesses divided by the total number of articles online for that journal, and is a way to "compare the usage of journals that offer widely different numbers of articles online"[31] could be explored to see whether there is a correlation with impact factors. Nevertheless, findings from the current study call into question using impact factors for local library decisions on journal collections.

The findings of this study not only contribute to our knowledge of citation data (local citation is a valid measure of journal use while global impact factors may not be) but also address practical questions of academic library collection measures. For example, the results from this study indicate that, although reading an article and citing an article are different activities, and perhaps indicate different usefulness of an article, there is an overall correlation between journals that are looked at online, and those that are cited by local researchers, something that one could not necessarily assume at an academic institution where non-publishing students are presumably a large population of online journal readers. It could be expected that, in a setting where *all* users of online journals are researching and publishing (e.g. a research center), such a correlation may even be stronger. It should be noted that the conclusions from the study are based on a single university library and on particular academic fields. More research needs to be conducted to determine whether the conclusions can be generalized to other areas of academic study before electronic journal usage data become a standard tool in helping shape journal collections. Meanwhile, other more subjective and traditional means of evaluating library journal collections (e.g. consultation with faculty) should still be used in combination with the newer electronic usage data.

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