Validating Online Reference Managers for Scholarly Impact Measurement

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Abstract

This paper investigates whether CiteULike and Mendeley are useful for measuring scholarly impact, using a sample of 1613 papers published in Nature and Science in 2007. Traditional citation counts from the Web of Science (WoS) were used as benchmarks to compare with the number of users who bookmarked the articles in one of the two free online reference manager sites. Statistically significant correlations were found between the user counts and the corresponding WoS citation counts, suggesting that this type of impact is related in some way to traditional citation-based scholarly impact but the number of users of these systems seems to be still too small for them to challenge traditional citation indexes.

Introduction

Research evaluation and assessment are important processes in academia for tenure track, funding allocation and research quality filtering purposes. As peer-review is not only time consuming but also expensive, traditional citation-based bibliometric quantitative methods have been widely used to evaluate scholarly impact at individual, departmental, university and national levels for over five decades (Moed, 2005). However, citation analysis is limited by the bibliographic databases where citation data is gathered. For example, the Web of Science (WoS) and Elsevier's Scopus, which index selected academic documents, are the two main bibliographic databases for conducting citation analysis. Citations in publications not indexed by these databases are simply lost.

With the development of the Web, scholars have more ways to communicate and disseminate research than ever before. These venues include open access archives, online journals, wikis, blogs, Facebook and Twitter. Cronin (2001) stated that the 'totality of ways in which cognitive influence is exercised and exhibited within and across specialty groups' on the web is hard to capture using traditional bibliometric methods alone. Although peer-reviewed print publications are still the 'hard currency' of the scholarly community (Research Information Network, 2010), innovative techniques are necessary to capture a more complete picture of scholarly impact in the web era.

A number of researchers have worked on identifying new quantitative research evaluation methods for the web to complement traditional citation analysis (Burgelman, Osimo, & Bogdanowicz, 2010; Priem & Hemminger, 2010; Thelwall, 2008). Two approaches are common: Web Citation Analysis (Vaughan & Shaw, 2005), which extends traditional citation analysis to the web; and Web Usage Analysis, which evaluates scholarly impact through potential readership statistics, e.g. article online views or downloads. This article assesses one potential new web-based source of online impact evidence: usage in free online reference managers like Mendeley, CiteULike and Connotea.

Related research

Web citation analysis

Web citation analysis refers to the counting of citations to academic publications from web-based sources. Cronin et al. (1998) have analyzed how influential five prominent library and information faculty members were through the use of five then popular search engines. Although the study searched the names of the five faculty members rather than their publications, it revealed that web mentions are different from traditional citations and that scholars use the web in different ways.

With the rise of search engines, researchers have gathered data on how scholarly papers are cited on the web through Google (Kousha & Thelwall, 2007; Vaughan & Shaw, 2003, 2005), Google Scholar (Kousha & Thelwall, 2007; Kousha & Thelwall, 2008; Meho & Yang, 2007; Norris & Oppenheim, 2010), Google Books (Kousha & Thelwall, 2009) and blog searching (Kousha, Thelwall, & Rezaie, 2010). The impact of scholarship on special types of documents, such as presentations (Thelwall & Kousha, 2008) and course reading lists (Kousha & Thelwall, 2008) has also been investigated. Many of these studies have found statistically significant correlations between traditional and web-based citation counts and reinforce the idea that the web is a rich source of information for measuring scholarly impact. However, web mentions can be trivial, such as contents lists of journals rather than reference lists of publications. In comparison, Google scholar works more like an extended bibliometric database but contains many types of publications, like preprints, conference papers, theses, and books (Google, 2010), that are outside WoS and Scopus and can therefore reflect a wider type of scholarly impact.

Web Usage Analysis

Digital libraries, online databases and online journals allow readers to view or download individual papers and automatically record the number of accesses of each resource. These usage statistics have the potential to disclose article popularity or readership size, which may be a good indicator of its value or scholarly impact. Early usage data gathered from a digital library were found to correlate with future citation counts (Brody, Harnad, & Carr, 2006), suggesting that usage statistics are related to scholarly impact but the correlation is not high enough to suggest that citations and usage statistics measure the same thing.

There are some practical problems that currently prevent usage statistics from being used for research evaluation. Publishers may provide both usage and citation data to journal editors but may not be willing to share their usage data to a third party for consolidation and calculation (Shepherd, 2007). Moreover, methods for gathering statistics are not yet uniform and hence large scale standardized data would not be achievable, even were publishers to make their data available. Furthermore, both view and download counts can easily be inflated by automated software (Taraborelli, 2008) and so it would be difficult to control gaming attempts should this type of metric become widely adopted to make tenure track or funding allocation decisions. As a result, web usage analysis is not promising for most research evaluation purposes.

Online Reference Managers

Online reference managers are web sites that allow users to save reference information online in reference libraries and share this information with others. The number of users who save a particular paper potentially indicates its readership size. In the current article, we call this number the *user count* of a paper. Whereas scholarly citations typically acknowledge intellectual debt to other work, user counts may indicate the readership of an article. Of course, it is likely that a tiny minority of the readers of an article will save it to an online

reference manager and it is also likely that some users save an article to an online reference manager without reading it, perhaps because they intend to read it later. Nevertheless, it seems likely that more frequently saved articles are likely to be more frequently read. Hence user counts may indicate the influence of published research.

A number of researchers have seen the potential of online reference managers for indicating the impact or value of a paper based on user counts (Priem & Hemminger, 2010; Taraborelli, 2008). The journal PLoS ONE (2009a) has also used CiteULike and Connotea statistics as part of its indicators, presumably to help readers to identify high impact or high quality papers. However, no existing research has validated the usefulness of user counts for research impact evaluation. Priem & Hemminger (2010) compiled a comprehensive list of potential web research evaluation tools which includes online reference managers and other social media tools, e.g. social bookmarking, recommendation systems, blogging, microblogging, and Wikipedia. Although they suggested possible steps toward building and validating these new metrics, they did not conduct any experimental research to validate the usefulness of those tools. Taraborelli (2008) argues that evaluation models based on online reference managers are relevant for measuring scientific impact. However, he focused more on the usefulness of collaborative annotation data mining rather than user counts, again without any experimental evaluation. Henning (2010) reports the top 10 most read articles published in 2009 through Mendeley user statistics and found a strong linear relationship ($r = .76$) between citations received by the five most popular biology papers ranked by WoS in 2009 and Mendeley user counts. However, larger scale studies have not been conducted yet.

Whether an online reference manager can be used for research evaluation purposes depends partly on whether it provides user counts. For example, RefWorks, EndNote and Zotero do not provide this data and therefore cannot be employed for research evaluation. To be useful for research evaluation, an online reference manager also needs to have a large number of users. Both CiteULike and Connotea were launched in 2004, but their uptake by academics seems to be low, according to PLoS ONE (2009b), CiteULike has more registered users than Connotea. Both of these online reference managers can also be categorized as social bookmarking tools, along with other sites, such as Delicious and Furl, which allow users to save web pages rather than reference items. Even for this more general type of site, uptake has not been high: Ginsparg (2007) reported that less than 10% of academics surveyed had used social bookmarking sites and only 1% found them to be useful. Another survey conducted by the Publishing Research Consortium reported that about 7% of respondents used social bookmarking tools (Ware & Monkman, 2008). The adoption rate of CiteULike and Connotea is likely to be lower, even though the cited studies are a few years old, because the scholarly community may need some time to adopt these tools before they reach a significant percentage of academics.

In comparison, Mendeley, a new free online reference manager, seems to have attracted many users since it was launched in 2008. By 2010, Mendeley claimed to have 450,000 users from 11,200+ research institutions and to have indexed 32.9 million documents (compared with 3.5 million for CiteULike) (Mendeley, 2010). Mendeley seems to be a promising research evaluation tool. It applies the principles of music sharing site Last.fm to scholarly research (Henning & Reichelt, 2008). The Mendeley founders aimed to create an open, interdisciplinary database of research for user-based metrics and collaborative filtering (Henning & Reichelt, 2008). MendeleyMendeleyev also allows users to save pdf files to its desktop application and automatically extract bibliographic information for them, e.g. the most popular journals or authors or papers both in general and in particular subject areas. Users can insert citation data and generate reference lists in MS Word using the Mendeley Add-In while sharing bibliographic data with collaborators anywhere using its web applications.

In conclusion, new quantitative research evaluation methods need to be developed and validated to extend and complement traditional citation based bibliometric analysis in the same way that web citations from Google Scholar have already been investigated. Nevertheless, user counts seem to be a different type of metric than citations. There are no systematic studies to date to assess whether user counts could be useful for research evaluation purposes. This study aims to fill this gap.

Research questions

The primary goal of this paper is to assess whether user counts from online reference managers could be used for scholarly impact evaluation. The main method used in the studies reported above that evaluates new sources of information for research evaluation is the correlation test with WoS citation data. The idea behind this test is that any source measuring any type of scientific impact ought to correlate with some recognized measure of scientific impact, and WoS citations are the main metric used for this purpose. The following research questions drive the investigation.

Do user counts of articles in Mendeley or CiteULike correlate significantly with WoS citations for the same set of articles?

Do user counts from Mendeley or CiteULike measure different types of scholarly impact than citation counts from WoS or Google Scholar?

Method

Research Design

Currently, the top two most-read publication outlets according to Mendeley are Nature and Science. To ensure sufficient user counts to conduct meaningful correlation analysis, papers published in Nature and Science were selected for our sample. Both journals are indexed by WoS and are highly cited. Titles of papers were used to search user counts in Mendeley and CiteULike. To get sufficient papers for analysis, we included all papers published in Nature and Science during one calendar year (2007). This gave time to accumulate citations and user counts in all of the tools used in this study.

Based on the literature review, a number of studies have found statistically significant correlations between citation counts from WoS and Google Scholar although they typically have different coverage of research publications. Google Scholar citations were gathered in this study together with WoS citations to answer question 2 as citation counts from WoS and Google Scholar vs user counts from Mendeley and CiteULike may shed some light on whether these two metrics measure different types of scholarly impact.

Data

The data collection was conducted in the following stages.

Step 1: Extracting titles and times cited for Nature and Science articles from WoS

WoS's Advanced Search facility was used to limit Publication Name (Nature/Science), Time Span (From 2007 to 2007), Restrict Results (English and Article) and then select Title, times cited for the 793 Nature articles and 820 Science articles.

Step 2: Counting how many users have posted each title in CiteULike

CiteULike allows both title searches and formatted reference searches. Most title searches were straightforward. However, a title with a formula very often did not return a relevant search result. Consequently a new search was conducted without the formula. For short titles, formatted reference search was used instead of title search. In addition to these issues, users who posted a title can be individuals and also sometimes can be groups. A group was deemed to be an individual for the sake of simplicity.

Step 3: Counting how many users have saved each title in Mendeley
Mendeley allows title searches but not formatted reference searches. Nevertheless, it provides advanced search facilities which allow searching by title, author, abstract etc. The same strategies as in Step 2 were applied to handle the formula and group issues.
Step 4: Counting citations using Google Scholar
Article titles were searched as phrases using double quotes in Google Scholar. Most title searches were straightforward. The same strategies as Step 2 were applied to handle the formula issues.
In order to ensure consistency, all data were collected in July 2010.

Findings

Tables 1 and 2 list the summary statistics for the Nature and Science articles. The mean and median values for Google Scholar citation counts are all higher than WoS citation counts. The Mendeley mean and median user counts are higher than CiteULike but the citation counts are much higher than the user counts. Table 3 reports the 0 frequencies for the two online reference manager user counts to indicate how well the 1613 articles were covered in these two sites. Although Mendeley was launched in 2008 while CiteULike came into being in 2004, many more articles are covered in Mendeley than in CiteULike. More than one third of the articles were not saved by any user in CiteULike while only less than 8% of the articles were not saved by any user in Mendeley, confirming the likely broader user base for Medeley.

Table 1 Summary statistics for the 793 Nature articles.

	WoS_Citations	*GS_Citations*	*CiteULike*	*Mendeley*
Mean	78.06	90.88	2.37	10.71
Median	53	61	1	7
Kurtosis	22.00	23.76	77.56	24.42
Skewness	3.96	4.15	6.82	3.71
Maximum	884	1023	76	150
Minimum	1	1	0	0

Table 2 Summary statistics for the 820 Science articles.

	WoS_Citations	*GS_Citations*	*CiteULike*	*Mendeley*
Mean	69.12	81.17	2.50	8.89
Median	44	52	1	6
Kurtosis	24.98	23.46	31.13	12.12
Skewness	4.23	4.14	4.61	2.79
Maximum	789	953	51	88
Minimum	0	0	0	0

Table 3 Zero value frequencies

	CiteULike	*Mendeley*
Nature	304 (38.3%)	49 (6.2%)
Science	333 (40.6%)	59 (7.2%)

Given the high Kurtosis and Skewness for all four variables, Spearman rather than Pearson correlations were chosen (Tables 4 and 5). All correlations are statistically significant at the 1% level. The correlations between Google Scholar and WoS citations show a nearly perfect relationship, suggesting that the two are essentially equivalent measures of scholarly impact,

at least for these two journals. These correlations are higher than in a number of previous studies (Belew, 2005; Kousha & Thelwall, 2007; Vaughan & Shaw, 2008) of other sets of journals.

Table 4 Spearman correlations for Nature articles (* = statistically significant at the 5% level, ** = statistically significant at the 1% level, n=793)

	WoS Citations	*GS Citations*	*CiteULike*	*Mendeley*
WoS_Citations	1	0.957**	0.366**	0.559**
GS_Citations		1	0.396**	0.592**
CiteULike			1	0.586**
Mendeley				1

Table 5 Spearman correlations for Science articles (* = statistically significant at the 5% level, ** = statistically significant at the 1% level, n=820)

	WoS Citations	*GS Citations*	*CiteULike*	*Mendeley*
WoS_Citations	1	0.931**	0.304**	0.540**
GS_Citations		1	0.381**	0.603**
CiteULike			1	0.605**
Mendeley				1

Based on the guidelines of Cohen (1988), the correlations between Mendeley user counts and WoS/Google Scholar citation counts are high, while those for CiteULike are medium. Apart from the correlation between Google Scholar citations and Mendeley user counts for Nature articles, the correlations between user counts are slightly higher than those between user counts and citation counts for both Nature and Science articles. This may due to the fact that CiteULike and Mendeley user counts measure article readership while WoS citation counts measure article influence in research output. The lower correlations associated with CiteULike and Mendeley may be due to data sparseness: too low user counts to give reliable data.

Discussion and limitations

The research has a number of limitations. The statistical Correlation analysis has been used to validate that online reference management sites are useful in research evaluation. However, statistically significant correlations between two data sources never prove a causal relationship so we cannot conclude that high research impact, as measured by citations, causes high online reference manager user counts for articles. The assumption that users saving papers to their online reference manager accounts might indicate that the article has some value is consistent with the literature review but remains not fully proven. Direct interviews with online reference manager users are necessary for future studies in order to complement statistical analysis and to draw definite conclusions about the connection between online reference manager user counts and article impact.

The research studied 1613 journal papers published in Nature and Science during 2007 and it is possible that the results would not be true for other journals (e.g., from social science, the humanities or specialist scientific fields) or for other years. In particular, the conclusions are likely to be weaker for less popular journals. Further research should extend the reach of the samples over larger areas of literature and time periods.

For simplicity, both CiteULike and Mendeley user counts for groups were treated as 1. However, the influence of a paper saved in one person's library would not be equivalent to the same paper shared in a group account of seven researchers, for example. Finally, if online

reference manager use becomes more widespread then the way in which people use it may change, which may also alter its value for impact assessment.

To answer our first research question, the statistically significant correlations (see Tables 4-5) between Mendeley/CiteULike user counts and WoS citations serve as evidence that the two online reference managers may be valid sources for scholarly impact measurement, but further research would be needed to confirm this because the findings are for only two journals. The correlations between Mendeley user counts and WoS citations are consistently higher than those between CiteULike and WoS counts. Mendeley has also attracted more users than CiteULike (see Tables 1-3), and hence has more promise for measuring research impact.

In answer to question 2, Tables 4-5 illustrate that although the correlations between WoS and Google Scholar citations are much larger than those between CiteULike and Mendeley user counts, the latter are slightly higher than those between CiteULike/Mendeley user counts and WoS/Google Scholar citation counts. Although this may be due to the lower numbers for the two online reference management sites, it may also indicate that citations from different bibliographic databases measure similar scholarly impact while user counts in various online reference managers reflect a broader readership.

It seems clear that journal papers (with citations) that are subject to rigorous peer review are more reliable indicators of quality than online reference manager user counts because the act of saving a reference item merely indicates an intention to use it later, perhaps by a student or journalist rather than an academic researcher. Nevertheless, evidence of saving articles in individual reference libraries can perhaps form part of research assessment, given that the purpose of research articles saved is to be read, or to be used as candidate reference items in later research output, or possibly to be used for course-related purposes. This can measure a wider range of influence than citation based bibliometric methods. In addition, user counts have the potential to measure influence of all types of publications rather than those limited by the indexes of bibliographic databases. Users of online reference managers are a larger group than authors of saved items as there are more readers than authors. This fact may effectively stop self interest oriented gaming attempts to ensure a more objective research evaluation process than citation analysis where citation creators and receivers are the same group of people. Furthermore, user counts can be more current than citation counts as journal papers need time to be cited whereas once a paper is published, it can be saved in an online reference management tool immediately. In addition, WoS requires a subscription while CiteULike and Mendeley are free and provide APIs to their user databases making large-scale analysis possible.

In conclusion, this study suggests that online reference managers may be useful for the research impact measurement from the point of view of general readers. For this purpose, the largest current online reference manager site which provides a way to gather user counts is the logical choice: in the current study this means Mendeley rather than CiteULike. It is also recommended that online reference manager user data is used in conjunction with traditional citations and other webometric indicators (Kousha, Thelwall, & Rezaie, 2010), if possible.

Conclusions

The significant correlations between CiteULike/Mendeley user counts and WoS citations suggest that the two online reference managers can be used as additional sources of evidence for research evaluation. Whereas citation counts may give data on research influence from the author's point of view, user counts may indicate research impact from a general reader’s point of view. Nevertheless, the numbers extracted from the online reference management software were much smaller than the WoS citation counts, suggesting that the data will not be reliable enough unless these sites grow a much larger user base. This is especially the case given that

the study analysed two of the most popular journals and most authors will publish their research in much less popular venues, with presumably very low representation in online reference management sites. Although Mendeley is relatively new, it seems to have a more promising future for research evaluation than CiteULike because it recorded more reference items and attracted more users in the study.

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