Webometrics and Scholarly Communication: An Overview

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Abstract:

The hope that web links could be used to provide similar kinds of information to that extracted from traditional journal citations has been a key reason in motivating much Webometrics studies. Since 1996, journals and universities' web sites were central point of most Webometrics research in order to validate links as an important source of information for scholarly communication. Results of recent studies indicate that web hyperlinks can be related to scholarly measures, but no cause-effect relationship was claimed. This review attempts to illustrate results of key quantitative and qualitative link studies, especially on journals and university Web sites and to give aperspective for future Webometrics studies.

Keywords:

Webometrics; Link Analysis; Web Sites; Journals; Universities

1. Introduction

Since 1996, many articles have been written on Web links and their interesting nature for exploring a kind of scholarly communication with reasons to consider whether theories of bibliometrics, such as journal citations, can be applied to the Web environment (for example, Almind & Ingwersen, 1997; Rousseau, 1997; Ingwersen, 1998; Borgman & Furner, 2002). It is believed that Web is important source of information for quantitative studies in terms of formal scholarly communications (such as, electronic journals, preprints, academic web spaces) as well as informal scholarly communications (such as chat, email, discussion groups). Some of the above

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researches have drawn analogy between citation and web links. For instance, Rousseau (1997) used the term "Sitation" to refer to a cited site, Ingwersen (1998) proposed "Web Impact Factor" as web counterpart of ISI's Impact Factor; and Borgman & Furner (2002) discussed about analogy between "linking and citing" .

While structurally very similar, journal citations are refereed documents and therefore their production is subject to quality control and they are part of the mainstream of academic endeavor, whereas web hyperlinks have discussable natures in terms of their quality. In fact, some researchers believe that there are significant differences between bibliographic citation and web hyperlinks as referred by Egghe (2000) and van Raan (2001). So, it is obvious that the challenge of the current Webometrics studies is to investigate possible analogy between link and citation.

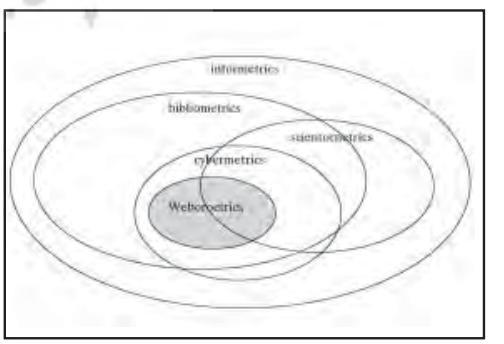
Although, it is possible to apply techniques of Webometrics on any web spaces with less scholarly characteristics, for instance newspapers' web sites (Kousha, 2004), to find some evidences for scholarly relationship, majority of studies were conducted on journals and university web sites. Findings of several quantitative studies in the recent years give us some evidences that there is a relationship between inlinks to journal web sites and their ISI impact. Such relationship found between links to university web sites and their national rankings or other research productivities in different national academic web spaces. However, no implicit causative connections have been claimed for the relationship between web links and research in the above studies. This paper reviews the results of related research on Webometrics and scholarly communication on the web in two parts: link studies on journals' web sites and link analysis of national academic web spaces. So, it won't cover all web hyperlinks studies.

2. Scholarly Communication on the Web: Methodological Issues

Borgman (2000, p. 144) described the scholarly communication "the study of how scholars in any field use and disseminate information through formal and informal channels. The study of scholarly communication includes the growth of scholarly information, the relationships among research areas and disciplines, information needs and uses of individual user groups, and the relationships among formal and informal method of communication". It is believed that web environment play a vital role in formal/ informal communications. But, the main question is that how we can measure the impact of such scholarly communication. Webometrics, the quantitative study of web-related phenomena, could be applied as a sloution.

Björneborn & Ingwersen (in press) have defined Webometrics as "the study of the quantitative aspects of the construction and use of information resources, structures and technologies on the WWW drawing on bibliometric and informetric approaches". They have also differentiated between concepts of Informetrics, bibliometrics, scientometrics, cybermetrics and Webometrics as shown in Figure 1.

Figure 1. The sizes of the overlapping between Informetrics, bibliometrics, scientometrics, cybermetrics and Webometrics (Björneborn & Ingwersen, in press) .



The aim of most Webometrics studies is to validate links as a new information source and to measure its impact on formal/informal communications. One of the key tasks is to compare the link data with other related online or offline data to investigate possible correlation between variables. With links between university web sites, for instance, a positive correlation between link counts and a measure of research would provide some evidence that link creation was not completely random and could be useful for studying scholarly communication. Moreover, comparing inlink counts to e-journals and e-articles with their ISI citation counts can present some evidence for analogy between web hyperlinking and bibliographic citation.

Comparing to traditional citation analysis, Webometrics research is facing several limitations, many of the related to nature of web environment itself. For example, invisible Web, that part of the web that is not accessible by search engines, is serious issue for Webometrics study. In fact, commercial search engines do not cover the entire Web. Lawrence & Giles, (1999) showed that even the largest search engine in 1999 covers less than 17% of web space. There are some other technical problems for locating web pages by search engines' crawlers. For instance, crawlers likely miss many isolated pages without any linked pages. Crawlers can not also index pages with links in the form of JavaScript, password-protected databases, temporarily down servers. Since, search options and accuracy of retrieval system is subject to change without notice, researchers always should check precision of the selected search engines for Webometrics studies. Because of the above limitation of commercial search engines, Thelwall (2001a) tried to design a specific crawler for data mining. Since, Webometrics is quantitative study of web, selection of a sample of pages or links is important. But, selecting unbiased sample from the web is very difficult and discussable, because we are facing with huge number of ever increasing of web pages which search engines can not index them. There are also some problems for displaying results in search engines. In fact, most search engines do not allow accessing more than the first 200-400 matches per each query.

3. Link Analysis of Journals' Web Sites

Vaughan & Thelwall (2003) considered three reasons for, why journal Web sites could play a critical role in scholarly communication: "the increasing use of the Web as an information source both inside and outside academia; the centrality of journals in disseminating scientific research; and the astonishing increase in the number of journals available through the Web in the last two years, including both the new electronic journals and traditional print journals having online versions". Thus, it is not surprising that much of Webometrics studies has been motivated by citation analysis, similar to techniques that are applied to citation analysis of journals.

Smith (1999) is one of the first researchers used citation analysis techniques to 22 Australasian refereed e-journals. He used AltaVista for link counting. Results showed no significant relationship between inlinks and ISI Impact Factors. He concluded that links to e-journals are different to citations because the former target the whole journal whereas the latter target individual articles. The factors not taken into account in Smith's study were the inlink counting of articles (instead of journals) and using qualitative methods (link creation motivations to journals).

Harter and Ford (2000) also studied on 39 scholarly e-journals not related to a specific discipline. Links to journals and articles were compared with ISI data set and no significant correlation found between link and ISI impact factors. Authors classified the

link creation motivation to about 300 sampled inlinks to "e-articles" into 13 categories. This was one of the early important studies using both quantitative and qualitative methodologies to validate the data. But selected journals were not related to a specific discipline to generalize the results at least to one discipline or among them. Moreover, link counting limited to one URL per e-journal, while authors mentioned there were several journals with different URL. While, classifying link creation motivations to e-articles is highly a subjective issue, authors did not mentioned anything about disagreement or agreement rate on exploring motivations by different classifiers.

Vaughan and Hysen (2002) analyzed journals of Library and Information Sciences that were indexed by the ISI. The journals in their study were not full-text e-journals but were traditional journals with independent web sites. The study found a significant correlation between the number of external links and the journal impact factor for LIS journals. Journals with higher journal impact factor scores tend to attract more links to their Web sites. The study also investigated issues pertaining to data collection methods for Webometrics research. It showed that the choice of search engine for data collection could affect the conclusion of a study. No qualitative study was conducted to validate the quantitative data (correlation between inlinks and ISI to selected journals).

Vaughan and Thelwall (2003) studied on 88 Law and 38 Library and Information Sciences S(LIS) journals indexed in ISI. The specific questions addressed in their study were: whether site age and site content are inducers of links to a journal's Web site .A new methodology for data collection is also introduced that uses the Internet Archives to obtain an earliest known creation date for Web sites. The results show that both site age and site content are significant factors for the disciplines studied. Journals with more online content tended to attract more links as did older journals web sites. An evidence was also found that link counts for LIS journals tended to be higher relative to their Impact Factor than was the case in Law.

Vaughan and Shaw (2003) took a different approach, comparing citations to journal articles from the ISI's index with citations (not hyperlinks) to them in the general Web. They used Google to collect web citation data. All papers published in 1997 in forty-six LIS journals were used in this large-scale exercise, which showed predominantly significant correlations, suggesting that online and offline citation impact are in some way similar phenomena. A classification of 854 web citations indicated that many "represented intellectual impact, coming from other papers posted on the Web (30%) or from class readings lists (12%). Results of this study can be considered important, because they manually checked and classified link creation motivations to journals' articles.

Kousha & Thelwall (2004) showed that 49% of sources of web citations targeting 282 research articles in 15 open access scholarly LIS journals were from 2000-2001. The study showed the impact of LIS e-journals in receiving the majority of citations within about one year after their publication on the web.

One question which was not covered in most Webometrics studies is the characteristics of sources of web citation equivalent to formal citation. Kousha & Thelwall extract macroscopic information from sources of web citations and showed that the majority of web citations to open access LIS journals were in PDF format (49.3%) and in English Language (81.5%). The study also showed that, 88.4% of web citations were from the full text documents and about 60% of citations to LIS e-journals were in the text format embedded in the body of citing sources.

Although, most of the Webometrics studies applied quantitative methods (correlation studies) and relatively little research directly explored motivations of link creation, Kim's (2000) study focused on motivations for hyperlinking in scholarly electronic articles. 15 authors were selected for interview and 180 outlinks in e-articles were manually examined for cross-checking of expressed motivations. In fact, this was another approach to explore motivations for creating hyperlinks from e-articles to other internet sources. 19 different hyperlinking motivations classified into the three motivational groups—scholarly, social, and technological. He conclude that in scholarly electronic environments scholars use hyperlinks for a variety of scholarly and non-scholarly purposes, and that hyperlinking is multidimensional behavior involving different levels of motivations. The small sample of e-articles in this study should be taken into account for generalizing the results.

Using CiteSeer, Goodrum, et al. (2001) analyzed citation patterns in online PostScript and PDF formatted computer science papers, finding significant differences when compared to comparable citation figures from the ISI. In particular, conference papers were more frequently cited online, accounting for 15% of citations from this source, but only 3% of citations were from ISI computer science papers.

Lawrence (2001) investigated online computer science research, finding papers that were publicly available online to be more frequently cited (in the ISI index) than those that were not. It seems likely that placing published articles freely online can generate more interest and facilitate easy access for other scholars, although the converse is probably also true: scholars may publish their most popular articles online. Harnad and Car (2000) have shown how citations can be turned into links and the related eprint archive initiative has built in many log file based tools for analyzing usage patterns.

We can conclude that most of the recent researches on journals were limited to one discipline (library and information science) as well as journals which were indexed in ISI database (most of them are not electronic-only journals), Vaughan and Hysen (2002); Vaughan and Thelwall (2003); Vaughan and Shaw (2003). Other previous studies on e-journals did not cover one specific discipline. So, it is difficult to generalize the results of them to all disciplines, Smith (1999); Harter and Ford (2000); Kim (2000). Reviewing the results of the above research indicates that while in 1999-2000 no significant correlation were claimed between inlinks to journals web sites or e-articles, more recent studies have found significant relationships. It seems that more current researches, especially on refereed electronic only journals in different disciplines can provide more critical evidences on relationship between web link and scholarly communication.

4. Link Studies on National Academic Web Spaces

National universities' web spaces have been center of attention in the most current link analysis research. Similar to link analysis of journals, early studies on university web sites tried to show that if link count could correlate with research measures. This was a reasonable attempt to validate links as an important source of information for scholarly communication.

Ingwersen (1998) in his highly cited article proposed a new measurement for calculating the online impact of areas of the Web, including university web sites. Web Impact Factor (WIF) was considered to determine the average online impact of a web site. This was proposed by counting the inlinking pages divided by the number of pages inside the web space. The study analyses a selection of seven small and medium scale national and four large web domains as well as six institutional web sites over a series of snapshots taken of the

Web during a month. The WIF was later modified for universities by dividing inlinks to full-time academic members of staff (Thelwall, 2001c).

Until 2000, no correlation was found between links and research measures in the academic web space (Smith, 1999; Thelwall, 2000). But, results of several recent quantitative research studies indicate that there is a relationship between links to university web sites and their national rankings or other research productivities in different national academic web spaces, including UK (Thelwall, 2001b); Australia (Smith & Thelwall, 2002); mainland China (Tang & Thelwall, 2002); Taiwan (Thelwall & Tang, 2003); Iran (Kousha & Horri, 2004) and Canada (Vaughan & Thelwall, in press). Other studies show that there is an even more significant correlation between research-oriented inlinks and research productivities in an academic web spaces (Thelwall, 2001b; Thelwall & Harries, 2003). However, no implicit causative connections have been claimed for the relationship between web links and research in the above studies.

Thelwall's (2001b) study was the first research which found significant correlatation between counts of links to on 25 UK universities and their average research productivity. In the Smith and Thelwall's (2001) study second evidence of relationship was found in the Australian academic web spaces. In this research, the number of academic staff were introduced to represent the size of universities, replacing Ingwersen's method for calculating WIF (Web pages in the domain as the denominator).

Thelwall & Harries (2003) consider three interconnected issues related to the validity and interpretation of the quantitative results of link analysis studies in academic web spaces: categorization (What kind of pages are linked to?); motivation (Why do scholars link to these pages at other universities?); and host university research relationships (what is the cause of the relationship between the research conducted at a university and the propensity of others to link to its pages?) Exploring link creation motivations, discussed in some related research, would be next important step to provide some validity to previous quantitative link analysis studies on the web (Thelwall, 2003; Wilkinson et al, 2003). The exact recognition of link motivations by authors of web sites is a subjective issue. Therefore, in some cases, there are a number of limitations in extracting and identifying real author motivations for creating links, even through the application of qualitative methods. Similar subjective problems can be viewed in other research areas of information science such as traditional citation analysis (for example classifying the motivations for citations to journal articles) and the concept of relevance in information retrieval (retrieving relevant documents based on users' information needs).

5. Link Creation Motivation Studies: Qualitative Approach

The key questions raised in some of the related studies are as follows. What is the cause of the correlation between the inlinks and research within an academic web space? Are inlinks or even academic inlinks to universities web sites representatives of formal scholarly communications or are there possibilities for randomly link creation or for informal scholarly activities? Consequently, it seems necessary to explore reasons for the significant correlations found between links and research. One approach to answer such questions is to use qualitative methods to interpret the results of the previous quantitative research

Thelwall & Harries (2003) consider three interconnected issues related to the validity and interpretation of the quantitative results of link analysis studies, especially in academic web spaces: categorization (What kind of

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Wilkinson et al. (2003) took a random collection of 414 links from ac.uk domain and classified them based upon the researchers' assessments. The inter-classifier agreement was found to be problematic, because of multiple potential motivations. The results showed that the majority of links (over 90%) were created for broadly scholarly reasons by researchers or students and only two were equivalent to journal citations. It was concluded that academic web link metrics will be dominated by a range of informal types of scholarly communication. From the 414 links the researchers disagreed on the categorization for 120 (29%) since there was a clear overlap between certain categories, for example between student-related and research-related web links. It concluded that web links between UK universities (excluding e-journals) are very different from citations, but they can be seen as natural by-products of scholarly activities. Wilkinson's classification scheme consists of 10 categories related to reasons for link creation including, student learning material, information for students, research support and resources, research partners, recreational, page creators or sponsors, research references, tourist information, libraries and e-journals, and similar departments.

Thelwall (2003) took a sample of 100 random inter-site links to UK university home pages for a qualitative exploration. The investigation methodology was an inductive content analysis based on one person's interpretation of the link motivation, without cross-checking by additional classifiers. Initial classification scheme was drawn up based upon observations from previous web page analysis experiments that used similar approach. Four new types of common link motivations, which were unique to the web were postulated including, general navigational links; ownership links; social links; and gratuitous links.

Kousha & Horri, (2004) showed that inlinks from the .edu domain to 34 Iranian university web sites correlate strongly with a measure of their national research productivity. A survey of 440 valid links from the .edu domain indicated no links were created for formal scholarly reasons, equivalent to journal citations. Only 27% of links were created for informal scholarly communication reasons. The majority of the inlinks, 63%, were created for gratuitous or navigational reasons and about 10% were related to non-academic motivations. It is concluded that motivations for link creation to the Iranian national academic system are

probably influenced mainly by sociological issues.

Kousha & Thelwall (2004) study on 282 e-articles published in 2000 in 15 open access LIS journals showed that they have been targeted by 3045 users. The results indicated that 43 percent of links were related to formal scholarly communications equivalent to citation. 18 percent of links were related to informal scholarly reasons. 33% of links were created for navigational purposes and 6.2 percent for other unclear reasons. The most web citations to e-articles were respectively related to journals and online papers (20%); conference and workshops papers (9.9%); research and projects reports (6.9%); conference presentation (presentation file) (2.4%); online books and book chapters (2.4%); and thesis and dissertations (1.5%).

6. Conclusion

Although, since 1996 much research has been done on link analysis of web sites, it is not quiet clear whether web links can be related to formal scholarly measures. In fact, many researches used quantitative methods to study correlation between web links as an online variable and other offline or online research measures. While, such correlation studies are very important, no cause-effect conclusions can be obtained from them. The main question is that whether it is possible to extract some kind of formal scholarly communication from the web links, equivalent to traditional citation? It seems that Webometrics research area is too young to answer this fundamental question, but based upon the link creation motivation findings (discussed before in this article), we can say that there are several evidences that link counts measure are related to the wide range of types of informal scholarly reasons.

It seems that future Webometrics studies seek for reasons and motivations for link creation. The key qualitative research questions are: Which proportion of inlinks (external links) to web sites (such as, journals or universities) is related to formal / informal scholarly reasons (link creation motivation study)? What are the characteristics of those sources of web links equivalent to citation (extraction of macroscopic information from sources of web citations)? Is there any disciplinary differences? Which tools and methods are appropriate for Webometrics study in order to extract some kind of scholarly information from web links? Such critical questions can only be answered through application of qualitative methodologies. But, it seems that using such methods have their own limitations. For example, link creation motivation is a subjective issue and various judgments can be extracted from reasons for creating links, similar to concept of relevance in information retrieval.

It seems that another challenge of Webometrics is using statistical methods on the web environment. Search engines don't index all the web spaces. Thus, it is nearly impossible to access the unbiased coverage of the web for statistical tests. For example, search engines can not index the "invisible Web", (hidden content on the web which could not be crawled by search engines). Another statistical problem is related to sampling the web spaces and links to them. In other words, the sampling of web pages and links must be as random as possible. But this is not easy task, because in most cases we are facing with huge amount of sample web sites. In fact, the quantitative part of web is constantly growing and this make the sampling of web more difficult. Another question is related to human interpretation of link creation motivations. How many people (researchers, classifiers and etc) are involved in the process of classification of link creations? Which classification scheme will be used for classifying reasons for link creations? Such questions show the challenges for using statistical methods in Webometrics studies.

Search facilities of commercial search engines are constantly changing and this could be considered as a main obstacle for Webometrics studies. For instance, AltaVista and Alltheweb inlink search methods don't work anymore. In fact, Webometrics research area suffers from lack of the appropriate and stable measuring tools. It seems that the future challenges of Webometrics not only is related to quantitative methods (such as sampling the web pages and web links) and measuring tools (search engines for data collection), but also to qualitative methods (such as interpretation of web links and classification of link creation motivations). Although Webometrics is still a young research field, it is emerging ground for quantitative and qualitative researches in library and information science.

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