FROM BIBLIOMETRICS TO IMETRICS: THE CHANGING TERMINOLGIES OF QUANTITATIVE INFORMATION RESEARCH

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ABSTRACT

Quantitative Information Research holds great promise for analysis in a variety of academic disciplines. In order to facilitate understanding of this research field, the changes in differing terminologies and their definitions are presented. This study extends earlier research by gathering data from Proquest Dialog, a leading collection of electronic databases with authoritative content. A longitudinal study of twenty four years of the amount and frequency of use of various Quantitative Information Research terminologies is made. Findings include the identification of previously unknown trends and patterns of terminology usage.

Keywords: Information Metrics, Infometrics, Bibliometrics, Webometrics, IMetrics, Scientometrics

1. INTRODUCTION

Over time, the field that quantitatively studies information has been termed bibliometrics, informetrics, scientometrics, Webometrics and most recently iMetrics. This study compiles searches to understand trends in usage of these terms and predict future directions. Earlier studies have had similar objectives (Hood and Wilson, 2001; Sengupta, 1992), so this study is an extension and update of them. The historical background and interpretations of these terms and their frequency of use over time is presented. This will be grounded in data obtained from running online searches of these terms in relevant databases. An initial search of over 300 databases yielded a group of 44 that had prominent mention of a key term in the title field of 2013 articles. This group was used to compare the focal terms over the years 1990-2013. Ultimately searches over each of the 44 databases were conducted for each of the 5 focal terms for each of the years 1990-2013. That is 4x44x24= 4224 online searches were completed. These databases were accessed through a ProQuest Dialog Web portal.

We believe our methodology will be of interest and use to information scientists. The last large scale study of these terms (Hood and Wilson, 2001) reflects a relatively early time for Web-based utilities and thus the terms Webometrics and iMetrics were not considered by them. Hood and Wilson (2001) only mentioned the term Webmetrics parenthetically in the Conclusion section of their article, arguing that the study of this new term was best left up to research on the Web, and not the Dialog information services which they were using. Of course, ProQuest Dialog provides access to databases over the Web but if the Web is akin to the wide world of publicly accessible territory, ProQuest Dialog might be viewed as gated community that one must be a member of or an authorized visitor. Notably, in a later publication these authors expressed concern about solely relying on proprietary electronic database systems such as ProQuest Dialog to conduct *Informetrics* related research (Hood & Wilson, 2003).

In contrast, other researchers were already actively engaged in exploring how *Webometrics* could fit in the existing paradigms of *Informetrics* (Almind & Ingwersen, 1997; Björneborn & Ingwersen, 2001; Boudourides, Sigrist, & Alevizos, 1999).

2. BACKGROUND

Let us first create working definitions of all four terms, as derived from the extant literature.

2.1. Bibliometrics

The term "bibliometrics" is derived from "biblio" (from the Greek word for "book") and "metric" (from the Greek word for measure). An early use of the term "bibliometrics" was Pritchard (1969) in the *Journal of Documentation*. He referred to "bibliometrics" as the application of statistical modeling in library and information sciences. Borgman and Furner (2002) defined bibliometrics as the analysis of document

properties and related processes. Bibliometrics techniques include citation analysis (Moed, 2005), frequency analysis (Zipf, 1949), co-word analysis (Moed, 2005) or even the simple counting of the number publications by an author, the number of publications in a particular field or topic, or even simply the number of publications in a specific journal.(Brookes, 1988, 1990; Peritz, 1990). The majority of applications of bibliometrics has been in the analysis of documents in the sciences. This has led to the use of the term "scientometrics" (Braun, 1994 ; Macias-Chapula, 1999; Roussea, 2000).

2.2. Scientometrics

Garfield (1973) defined "scientometrics" as a field of inquiry for quantitative analysis of science and scientific fields of research, in differentiation to "bibliometrics" which covers the gamut of publications. The term "scientometrics" became more prominent with the advent of the journal *Scientometrics* (Afshar, Abdulmajid, Hakimi, & Majidfard, 2012). The development of the Institute for Scientific Information's (ISI) *Science Citation Index* (SCI) in the 1960's (Garfield & Merton, 1979) and then the *Social Science Citation Index* (SSCI) (Garfield & Welljams-Dorof, 1992) and the *Humanities Citation Index* (HCI) (Thelwall, 2008) enabled new applications of bibliometrics and scientometrics. The original intention of these citations indexes was to assist researchers by identifying streams of literature relevant to their own research, and help identify the relative importance and influence of particular publications, articles and researchers (Nederhof, 2006).

Drawing on Thelwall (2008), an overview of scientometric research can be described as using the numbers of article citations, articles, other publications or research topics to evaluate the relative import of different research and to examine the interconnection of citations of articles to provide scholars with insights on appropriate direction within streams of research of their own research. Scientometrics techniques can be used for meta-analysis of citation indexes. Also impact factors can also be readily generated (Brown, 2007; Weingart, 2005). However, the development and use of impact factors is controversial (Amin & Mabe, 2000; Kapeller, 2010; Klein & Chiang, 2004; Macri & Sinha, 2006). Notably, their meaning and validity as measures of the quality of publications counted and their use for such purposes as ranking universities have both supporters (Jeung, Yoon, Park, & Jo, 2011; Macdonald & Kam, 2010; Pomfret, 2007) and detractors (Aguillo, Ortega, & Fernández, 2008; Pomfret, 2007; Reed, 1995). Institutions with tight budgets sometimes use such measures of journal quality to guide their library acquisitions (Bencetić Klaić & Klaić, 2004; Klaic, 1997; Marušiæ & Marušiæ, 1999).

The use of such measures in developing nations like China that are aggressively seeking to improve the world rankings of their universities and researchers is hotly debated (Chun, 2012; Jianlin & Mingjun, 2004; J.-w. Liu & Su, 2006; Pu, 2008; Xin-Ning, Xin-Ming, & Xin-Ning, 2001; Xinning, 2001). Although steeped in a millennia of scholarly tradition, modern Chinese scholars are only recently coming to grips with the need to align with global metrics of academic quality (N. C. Liu & Liu, 2005; Sadlak & Liu, 2007; Slaughter & Leslie, 1997). Thus, nested in a technologically sophisticated culture and economy, Chinese universities and scholars use scientometrics to improve their rankings (Altbach, Reisberg, & Rumbley, 2009; Huang, 2011; Tang & Thelwall, 2002).

2.3. Informetrics

Because of the overlap between bibliometrics and scientometrics, which generated confusion among scholars, a broader term was desirable. Nacke (1979) proposed "informetrics" as a term to describe the part of information science that covered the measurement of information phenomena by applying mathematical models to information science research. Bonitz (1982) and others have discussed the introduction of this new term "informetrics" and compared the term with "bibliometrics" and "scientometrics."

The All-Union Institute for Scientific and Technical Information in 1984 through the Federation de Internationale de la Documentation (FID) Committee, perhaps not surprisingly under the chairmanship of Dr. Nacke, sought to clarify terminology. Ultimately "informetrics" was adopted as a generic term covering both "bibliometrics" and "scientometrics" (Glanzel & Kretschmer, 1994; Koenig & Bookstein, 1995; Marshakova-Shaikevich, 1993).

2.4. Webometrics

With advances in information technology, notably the World Wide Web, yet another Quantitative Information Research term was needed. "Webometrics" came into use as a direct response to the unique aspects of the World Wide Web (Almind & Ingwersen, 1997; Bar-Ilan, 2008). Webometrics draws upon the mathematical modeling of informetrics, to analyze problems traditionally done by bibliometric and scientometric methods. A broad definition of "Webometrics" is the study of Web-based content largely through quantitative methods for research goals using techniques not inherently specific to a particular field of study (Vaughan & Thelwall, 2004). HTML's inventor and creator of the first Website Dr. Tim Berners-Lee sought to create worldwide network of linked scientific papers (Wilkinson, Harries, Thelwall, & Price, 2003). The early Web indeed consisted mostly of scholarly documents but lacked an effective means for facilely locating the desired research articles (Björneborn & Ingwersen, 2004; Kousha & Thelwall, 2007). In order to help achieve Berners-Lee's intention of using the Web as a means for sharing scientific research,

Brin and Page (1998) outlined a proposal for a search engine that would facilitate the identification, location, and proliferation of scholarly articles. The theories developed in this paper were the basis for their later founding of the pre-eminent search engine Google. Only after their financial success did Google return to its original vision by creating Google Scholar (Noruzi, 2005). With the commercialization of the Web, and with it the proprietary ranking of Webpages by not just Google (Ingwersen, 2006) but other search engines like Yahoo! (Vaughan & You, 2010), and later Bing (Thelwall & Sud, 2012), the term Webometrics came into use by informetrics researchers (Jansen & Molina, 2006; Lewandowski, 2008; McCown & Nelson, 2007; Vaughan, 2004). Like scientometrics before it, there are two key aspects of Webometrics: Link analysis (Vaughan & Thelwall, 2004; Vaughan & You, 2010) and Web citation analysis (Thelwall, 2001). Also included is the quantitative study of the number of hyperlinks to Webpages, and the network relations among these links. Searches using the Google search engine derive their results from a combination of these link analysis and Web citation analysis which rank the relative importance of a Website (Brin & Page, 1998; Stock & Stock, 2006b).

Because of the need to understand the links and citations among Web pages for both academic (Alexander, 2006; Hsu & Park, 2011) and business reasons (Brengman & Karimov, 2012; Rosen, Barnett, & Kim, 2011; Rosen, Lafontaine, & Hendrickson, 2011), Webometrics continues to be an important subfield of informetrics (Ferri, Grifoni, & Guzzo, 2012; Stieglitz & Dang-Xuan, 2012; Vaughan & Thelwall, 2004; Weber & Monge, 2011). However, using Webometrics analytic techniques on the Web itself has limitations for the researcher. Unlike standardized and verified information as found in databases like those vended by ProQuest Dialog, the varying content type (Ortega & Aguillo, 2013) and content accuracy (Orduña-Malea & Regazzi, 2013; Vaughan & Yang, 2013) of Web sites and individual Web pages comes into question. Any academic who has read a student paper plagiarized from Wikipedia can readily grasp these hazards (Denning, Horning, Parnas, & Weinstein, 2005; Kittur, Chi, Pendleton, Suh, & Mytkowicz, 2007; Voss, 2005). In order to overcome these researches concerns and remain congruent with the method used by Hood and Wilson (2001) as identified in the Introduction, this paper's analysis also used ProQuest Dialog databases for the data source.

2.5. iMetrics

A new term has been introduced "information metrics" or abbreviated as "iMetrics" that is meant to encompass "bibliometrics," "scientometrics", "informetrics" and "Webometrics" (Milojević & Leydesdorff, 2013). The notion is that while these areas of study had different roots, currently they have many methods in common, are often indistinguishable (De Bellis, 2009), and these terms are used interchangeably (Glänzel & Schoepflin, 1994; Bar-Ilan, 2008). We did searches of this term for the years 1990-2013 as we had done for the other four terms but found scant items with it in their titles so far. Indeed the number of uses of the term for extraneous things is significant.

3. METHODOLOGY

This study undertook a comparison of the main terms for information metrics and their usage and corresponding importance from 1990-2013. These terms are: informetrics, scientometrics, bibliometrics and Webometrics. An additional new term "information metrics" abbreviated iMetrics was studied but found to have too low a level of usage to meaningfully assess at this point. The authors set out to

examine more than 300 databases by getting a grant for unlimited research access from the top database vendor and portal ProQuest Dialog. Using this access we searched all the databases available through the DialogWeb portal and found that 44 databases had keywords such as "bibliometrics" in the title of items (largely articles) in the title field. This field was chosen to avoid inconsistencies among databases in the provision and coding of fields such as abstract, descriptors, and full text. For example, if a database like ABI-Inform has the full text of articles comparing it to one such as Social SciSearch that does not would distort the number of relevant articles comparatively offered. Worse, if one had a descriptor (keyword) index which labeled all the articles on information metrics with just one term, say "informetrics", then that would distort the actual use in the journals within the database. The timeframe 1990-2013 (24 years) was chosen to give us a pre-Web baseline. We logged into ProQuest Dialog and searched more than 300 databases to locate the focal 44 ones mentioned above.

For each of these searches were run for each separate year from 1990-2013 for each of the four terms, requiring 4224 searches (4 x 44 x 24). The terms were coded into search syntax using a wild-card character at the end of the short form to allow for both the adjectival and noun forms of the terms. For example, using "informetric?" to solicit both articles having "informetric" and "informetrics". These data were then analyzed using tables and charts.

4. FINDINGS

TABLE 1: QUERY RESULTS WITH ANNUAL BREAKDOWN OF USAGE FOR EACH TERM

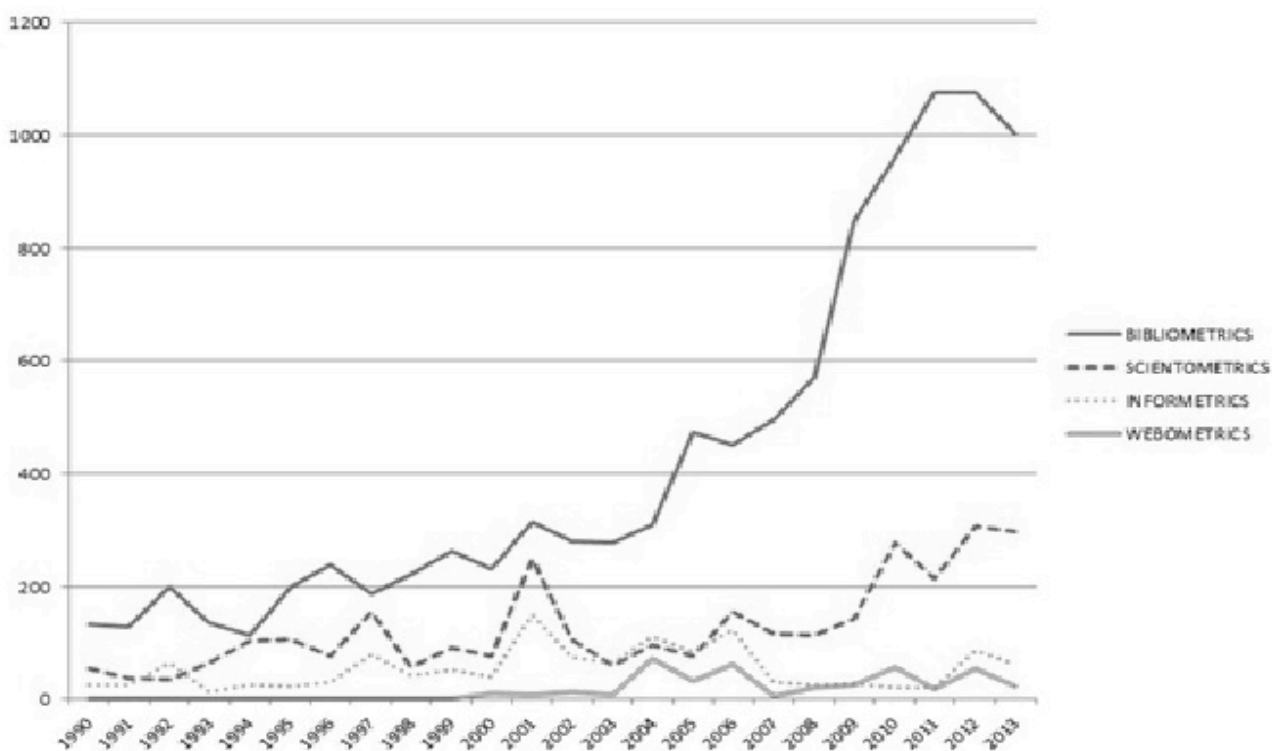| Year	BIBLIOMETRICS	SCIENTOMETRICS	INFORMETRICS	WEBOMETRICS
1990	134	55	26	0
1991	129	37	26	0
1992	200	34	64	0
1993	136	65	12	0
1994	114	104	24	0
1995	198	107	22	0
1996	237	77	29	0
1997	187	154	80	0
1998	221	56	42	0
1999	262	90	51	0
2000	231	77	39	10
2001	315	249	151	9
2002	279	106	73	12
2003	278	59	64	8
2004	309	97	111	72
2005	473	76	84	32
2006	451	154	124	61
2007	496	116	30	5
2008	571	114	24	19
2009	849	143	28	26
2010	960	277	21	56
2011	1077	214	19	17
2012	1077	307	86	55
2013	1002	298	61	23

Source: Authors' Research

TABLE 2: TOTAL NUMBER OF TERMS BY TIME PERIODS

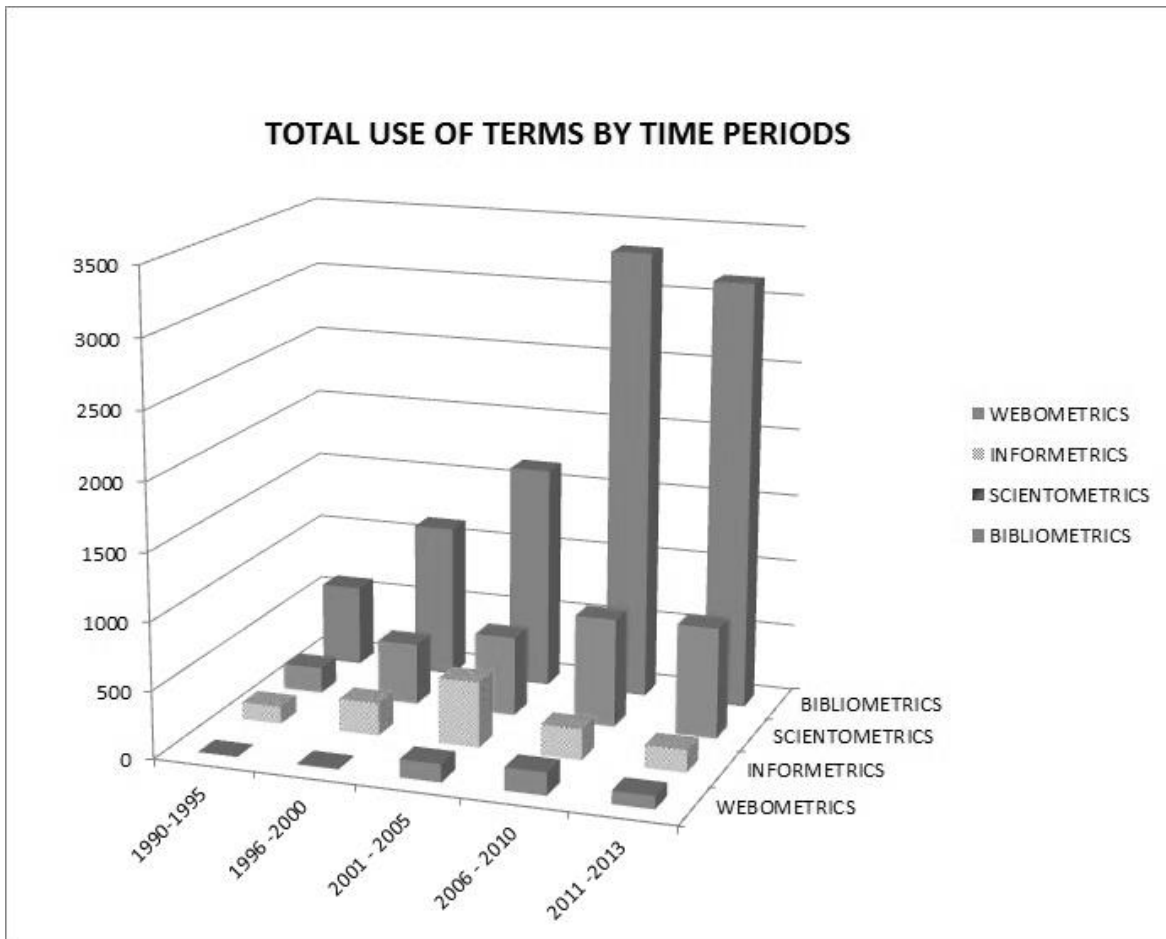| Period	WEBOMETRICS	INFORMETRICS	SCIENTOMETRICS	BIBLIOMETRICS
1990-1995	0	128	191	599
1996 -2000	10	241	454	1138
2001 - 2005	133	483	587	1654
2006 - 2010	167	227	804	3327
2011 -2013	95	166	819	3156

Source: Authors' Research

FIGURE 1: USE OF TERM BY YEAR

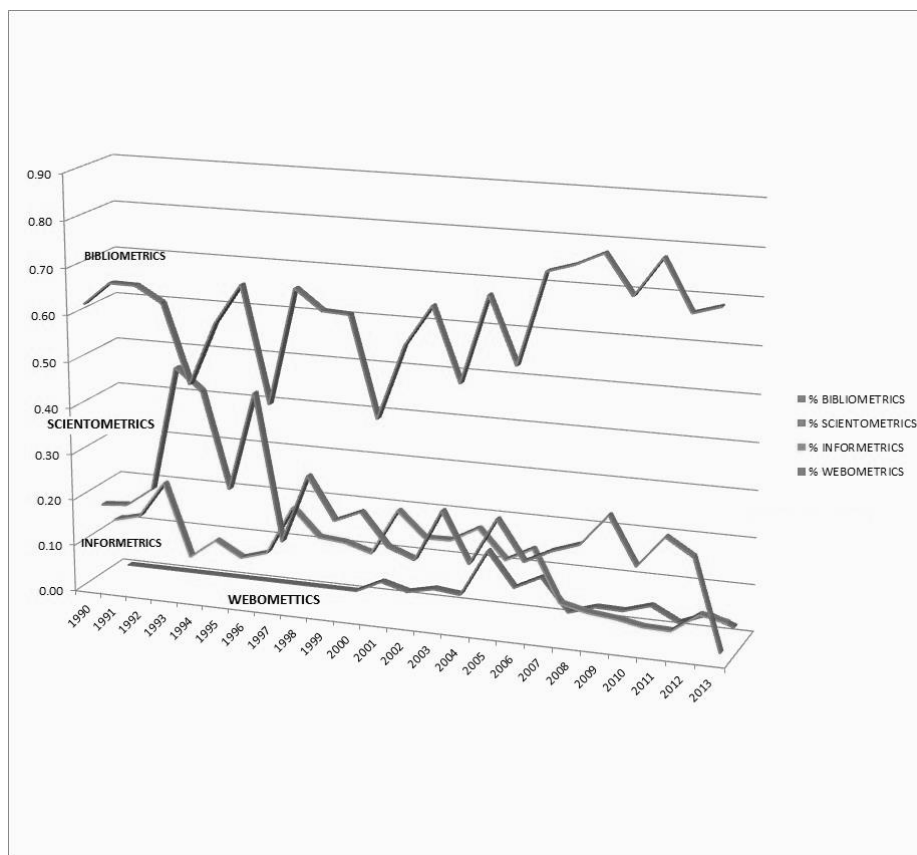### 4.1 Observations on Figure 1

- Bibliometrics is the predominant term, followed by Scientometrics, Informetrics, and Webometrics.
- In 1999 to 2002, a spike in Scientometrics, and Webomterics term introduced

- Webometrics use rises and falls between 2003 and 2013, almost appears cyclical
- Steady Increase in the use of all these terms, especially since 2004

FIGURE 2: TOTAL USE OF TERMS BY TIME PERIOD

TOTAL USE OF TERMS BY TIME PERIODS

4.2 Observations on Figure 2

- From 2001 to 2005, Informetrics gaining ground with Scientometrics
- From 2006 – 2013, use of Informetrics falls off sharply
- From 2006 – 2103, use of Scientometrics remains steady
- Use of Webometrics comes into vogue in 2001 onwards
- Use of term Bibliometrics soars from 2006 onward

FIGURE 3: PERCENTAGE OF USE OF EACH TERM ANNUALY

4.3 Observations on Figure 3

- Changes in Percentage Use of Bibliometrics and Scientometrics fluctuate concurrently
- Decreases in Use of these terms correspond to Increase in Use of Webometrics and Informetrics
- From 2007 onwards downward trend in use of Informetrics and Webometrics
- From 2007 onwards Bibliometrics and Scientometrics again on the rise

5. DISCUSSION

Based on our search results shown in Tables 1 and 2, and graphed in Figure 1 , bibliometrics is by far the most widely used term. The next most commonly used term is scientometrics. The two newer terms informetrics and Webometrics place a distant third and fourth. This is true for all time periods for which data is drawn, from the years 1990 - 2013. This supports earlier research findings. Our research extends these extends these findings by incorporating the term Webometrics in the data collection and analysis. Our research when presented graphically show trends that have not been addressed in the literature.

5.1 Emerging Trends

As shown in Figure 2, with the creation of the new terms informetrics and Webometrics, the older terms of bibliometrics and scientometrics make resurgence from 2004 onwards. Likewise, there is a marked increase in the number of uses of bibliometrics and scientometrics. From 2004 to 2013, there is a tripling of the number of uses of bibliometrics

In Figure 3, from 2000 to 2013, the use of the terms bibliometrics and scientometrics appear to correspond with one another. Fluctuations in usage over the 23 year time frame are synchronous. Increases in the use of one term correspond with increases in the other. Decreases correspond as well.

Also in Figure 3, in the late 1990s to the early 2000's, the new terms of informetrics and Webometrics start to become more popular. There is an inverse relationship between the use of these two new terms,

and the two older terms. As the use of informetrics and Webometrics increases. use of the terms bibliometrics and scientometrics decreases. Interestingly, the relationship between informetrics and Webometrics is similar to that of bibliometrics and Webometrics. In these two new terms as well, as one term increases (or decreases) so does the other.

The inverse relationship of usage between these two sets of terms (bibliometrics/scientometrics, and informetrics/ Webometrics) is a major contribution which is not found in the extant literature.

Likewise, the similarity between the congruent relationships of these two pairs (bibliometrics/scientometrics and informetrics/Webometrics) is an additional finding, all of which are worthy of further examination.

6. STUDY LIMITATIONS

There are several limitations to this research. The data is drawn from one electronic source, the ProQuest Dialog Web portal. The marked increase of the number of times these terms are used over time may reflect possible changes in the content available in the ProQuest Dialog databases. By examining other sources, our findings may be supported or denied.

Further, this study is taken from a macro-level of the databases within Proquest Dialog web portal. An analysis within the files of specific databases could be instructive to see whether these patterns we have observed are true on a more micro level. Applying this micro level analysis to other electronic sources as well would be instructive.

7. CONCLUSION

In this study we have examined the amount and frequency of use of changing terms in the field of Quantitative Information Research. From this data we have determined trends and patterns in the increases and decreases of the use of these terms. The identification of these trends may assist future researches as they seek to learn more about Quantitative Information Research. Future research can include analysis from additional data sources, in an effort to develop models to better identify and illustrate these trends and patterns of changes in terminology in Quantitative Information Research.

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