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Bibliometrics: An overview

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Abstract: Knowledge manager/Librarian have adopted a number of quantitative methods in recent years in order to evaluate library resources and services more objectively and effectively. Bibliometrics is one of the quantitative techniques applied by Librarians/ Knowledge managers. To evaluate the records of human communication it is used to identify the pattern of publication authorship, citation used for a subject etc. over a period of time and there by offering insight into the dynamics at the area, under a particular study. Bibliometrics has attained significance in recent years because of its practical applications in various library operations and services. It is estimated that out of the total periodical literature published in the library and information science at the global level 25% on bibliometric studies.

1. INTRODUCTION:

Bibliometrics is a set of techniques devoted to the quantitative analysis of scientific and technical activities. These techniques implement statistical and mathematical tools to measure the data that measure researcher's contributions to science and technical development. The data used for bibliometric studies mainly stem from information produced by the activity of researcher's communication. These quantitative studies of researcher's communication activities tend to have a better understanding of phenomena of construction, dissemination and use of scientific and technical knowledge. Bibliometrics is considered as a standard tool of science policy and research management in the last decades. All significant compilations of science indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques. The aim of bibliometric studies was to measure national research performance in the international context or to describe the development of a science field with the help of bibliometric means.

Today, bibliometrics is one of the rare truly interdisciplinary research fields extended to almost all scientific fields. Bibliometric methodology comprises components from mathematics, social sciences, natural sciences, engineering and even life sciences. Both bibliometrics and scientometrics are a set of methods used for measuring the production and dissemination of scientific knowledge.

Derek de Solla Price and Vasilij Vasilevich Nalimov were the originators of the discipline, which they developed for the purpose of providing research tools to historians and sociologists of science.

2. BIBLIOMETRICS:

Allan Pritchard was the first man who coined the term Bibliometrics in 1968 but it became more popular during 1980s.

According to D.T. Howkins "quantitative analysis of the bibliographical features of body of literature". Nicholas and Ritchie (1978), in their book entitled "Literature on Bibliometrics", stated that bibliometrics "Provide information about the structure of Knowledge and how it is communicated?" More recently Sengupta had defined this term as the "organization, classification and quantitative evolution of publication patterns of all macro and micro communications along their authorship by mathematical and statistical calculus".

3. HISTORY OF BIBLIOMETRICS:

Origin of Bibliometrics:

The word 'Bibliometrics' is coined by two words 'biblio' and 'metrics'. The word 'biblio' is derived from combination of a Latin and Greek word 'biblion', which means book, paper. On the other hand, the word 'metrics' indicates the science of meter i.e. measurement. The terms bibliometrics and scientometrics were almost simultaneously introduced by Pritchard and by Nalimov and Mulchenko in 1969.

Alan Prichard's definition in the introduction to statistical bibliography is: The statistical analysis of the means of

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communication in order to illuminate, the factors which influence them and the inter relationship between the history and sociology of a science and the literature of the sciences.

The term bibliometrics was first used by A. Prichard in 1969 to denote a new discipline where quantitative methods were employed to probe scientific communication process by measuring and analyzing various aspects of written documents. Etymologically bibliometrics is composed of two distinct parts i.e. Biblio and Metrics. The prefix biblio is Greek word meaning books and metrics means measurement to bibliometrics connotes the science of measurement of pertaining to books or document. The terms have been put forward by many authors.

Fairthrone defined bibliometrics as "The quantitative treatment as properties of recorded discourse and behaviour pertaining to it." The British Standards Institutions, "Bibliometrics as the study of the use of documents and patterns of publication in which mathematical and statistical methods have been applied" Raising in 1962 defined it as, "The assembling and interstation of statistical relating to books and journals".

Raising's definition is regarded as one of the classical definition of bibliometrics. Hawkins in 1977 in his online bibliometric study interpreted bibliometric study interpreted bibliometrics as quantitative analysis of the bibliographic feature of a body of literature.

Nichols and Ritchie define, "Bibliometrics provide information about the structure of knowledge and how it is communicated". They further added that, "Bibliometrics studies fall mainly into two broad categories those describing the characteristics of features of a literature (descriptive studies) and those examining the relationship formed between components of a literature (behavioural studies).

More recently, Potter defined bibliometrics as the study and measurement of the publication patterns all forms of written communication and their authorship.

While Pritchard explained the term bibliometrics as "the application of mathematical and statistical methods to books and other media of communication". Nalimov and Mulchenko defined scientometrics as "the application of those quantitative methods which are dealing with the analysis of science viewed as an information process".

According to these interpretations the speciality scientometrics is restricted to the measurement of science communication, whereas bibliometrics is designed to deal with more general information processes. The anyhow fuzzy borderlines between the two specialties almost vanished during the last three decades, and nowadays both terms are used almost as synonyms.

4. THE PIONEERS OF BIBLIOMETRICS

The statistical analysis of scientific literature began almost 50 years before the term "bibliometrics" was coined. In 1926, Alfred J. Lotka published his pioneering study on the frequency distribution of scientific productivity determined from a decennial index (1907- 1916) of Chemical Abstracts.

Lotka's Law describes the frequency of publication by authors in a given field. It states that " . . . the number (of authors) making n contributions is about $1/n^2$ of those making one; and the proportion of all contributors, that make a single contribution, is about 60 percent" (Lotka 1926, cited in Potter 1988). This means that out of all the authors in a given field, 60 percent will have just one publication, and 15 percent will have two publications ($1/2^2$ times .60). 7 percent of authors will have three publications ($1/3^2$ times .60), and so on.

According to Lotka's Law of scientific productivity, only six percent of the authors in a field will produce more than 10 articles. Lotka's Law, when applied to large bodies of literature over a fairly long period of time, could be accurate in general, but not statistically exact. It is often used to estimate the frequency with which authors will appear in an online catalog (Potter 1988)

At almost the same time, in 1927, Gross and Gross published their citation based study in order to aid the decision which chemistry periodicals should best purchased by small college libraries. In particular, they examined 3633 citations from the 1926 volume of the Journal of the American Chemical Society.

This study is considered the first citation analysis, although it is not a citation analysis in the sense of present-day bibliometrics. Eight years after Lotka's article appeared, Bradford (1934) published his study on the frequency distribution of papers over journals. Bradford's Law serves as a general guideline to librarians in determining the number of core journals in any given field. It states that journals in a single field could be divided into three parts, each containing the same number of articles: a core of journals on the subject, relatively few in number, that produces approximately one-third of all the articles, a second zone, containing the

same number of articles as the first, but a greater number of journals, and a third zone, containing the same number of articles as the second, but a still greater number of journals.

The mathematical relationship of the number of journals in the core to the first zone is a constant n and to the second zone the relationship is n^2. Bradford expressed this relationship as 1:n: n^2. Bradford formulated his law after studying a bibliography of geophysics, covering 326 journals in the field. He discovered that 9 journals contained 429 articles, 59 contained 499 articles, and 258 contained 404 articles. So it took 9 journals to contribute one-third of the articles, 5 times 9, or 45, to produce the next third, and 5 times 5 times 9, or 225, to produce the last third. As may be seen, Bradford's

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Law is not statistically accurate, strictly speaking. But it is still commonly used as a general rule of thumb (Potter 1988).

Zipf (1949) formulated an interesting law in bibliometrics and quantitative linguistics that he derived from the study of word frequency in a text. Zipf's Law is often used to predict the frequency of words within a text. The Law states that in a relatively lengthy text, if you "list the words occurring within that text in order of decreasing frequency, the rank of a word on that list multiplied by its frequency will equal a constant. The equation for this relationship is: r x f = k where r is the rank of the word, f is the frequency, and k is the constant (Potter 1988).

Zipf's illustrated his law with an analysis of James Joyce's Ulysses. "He showed that the tenth most frequent word occurred 2,653 times, the hundredth 6 most frequent word occurred 265 times, the two hundredth word occurred 133 times, and so on. Zipf's found, then that the rank of the word multiplied by the frequency of the word equals a constant that is approximately 26,500" (Potter 1988).

Zipf's Law, again, is not statistically perfect, but it is very useful for indexers. This situation dramatically changed when Derek deSolla Price published his fundamental work in bibliometrics.

5. BIBLIOMETRICS SINCE DESOLLA PRICE:

In his book entitled "Little Science – Big Science" (1963), Derek deSolla Price analysed the recent system of science communication and thus presented the first systematic approach to the structure of modern science applied to the science as a whole. At the same time, he laid the foundation of modern research evaluation techniques. DeSolla Price' work was more than pioneering; it was revolutionary. Time was now ripe for the reception of his ideas since globalisation of science communication, the growth of knowledge and published results, increasing specialisation as well as growing importance of interdisciplinarity in scientific research reached a stage where scientific information retrieval began to fail and funding systems based on personal knowledge and evaluations by peer reviews became more and more difficult. At that time, most basic models for scientific communication were developed. Among these are first models for essential concepts in scientific communication like growth and ageing of information.

Literature and information was assumed to grow exponentially, but in individual research disciplines the growth can also be linear or logistic. Finally, the logistic model has been widely accepted since both exponential and linear growth can be considered special phases within the logistic model. The concept of ageing or obsolescence is intimately linked with the growth of science. In information science and bibliometrics, changing frequency of citations given or received over time is assumed to reflect ageing of scientific literature. Some authors have downright considered growth and obsolescence inverse functions, the faster growth of literature in a field, the faster it ages and the literature becomes obsolete in a shorter time. Consequently, an exponential model has been proposed for the ageing of literature in the beginning, too. In particular, the model of radioactive decay has been adopted. Later on, more complex models have been developed.

Goffman and Nevill have introduced the theory of intellectual epidemics as a model of scientific communication in 1964. According to this model the diffusion of ideas in a population of scientists could be compared to the spreading of an influenza virus in a population of people, causing an epidemic. This model can be used both, to describe the spread of the disease and to predict the time when the disease reaches its peak, after which it is presumed to decline. The advantage of the model lies in its predictive power.

Goffman and Nevill proposed that the same model could also describe the spread of information within the scientific community. According to the model, the population can at any time be subdivided 8 into three groups of infected, resistant and infection sensitive persons. If a published article in a specific topic is considered an infection, it is possible to follow the diffusion of the epidemic by counting the number of publications per author and theoretically make a forecast of its future.

Communication between authors builds on attempts to distribute ideas aiming at reception of disseminated information and on providing contact between infection susceptible and already infected persons. In the beginning of the eighties, bibliometrics could evolve into a distinct scientific discipline with a specific research profile, several subfields and the corresponding scientific communication structures (publication of the international journal scientometrics in 1979 as the first periodical specialised on bibliometric topics, international conferences since 1983, the journal research evaluation since 1991).

The main reason for this development could be seen in the availability of large bibliographic databases in machine-readable form and the fast development of computer science and technology. This made it possible that metrics of science could be established also outside the USA. First, license fees and expensive CPU time resulted at least in the 80s in severe limitations but the technology of the 90s brought the breakthrough. "On-line bibliometrics", however, remained a dream. The funding of large projects seems to have become the regular way of financing research in scientometrics. From "Little Scientometrics" the field has become "Big Scientometrics"

Analogous terms:

Bibliometrics is just one of many sciences whose name ends with "metrics". Many scientists used the term under different

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names, but the concepts were more or less supplementary and complementary to each other with some broader and narrower extension of human ideas. One name that was used quite early but very scarcely was statistical analysis of the literature by Cole and Eales in 1917, while Hulme used the term 'statistical Bibliography' in 1923.

In 1948, the great Indian Library Scientist, S.R. Ranganathan, coined the term "Librametry", which historically appeared first and perhaps seemed proper to streamline the services of Librarianship. 'Librametry' term is to connote the use of statistic to evaluate an existing or proposed library services and resources. This term is a wider term which includes in it the concept of bibliometrics. But this term did not take its place in library science and was forgotten for many years. Later, it was called 'Librametrics.

The term 'Bibliometrics' is just analogous to Ranganathan's 'Librametrics', the Russian concept of 'Scientometrics', 'Informetrics' and to some other well established sub disciplines like'Econometrics','Psychometrics','Scientometrics','Bibliometrics','Technometrics','Chemometrics', where mathematical and statistical calculus have been systematically applied to study and solve problems in their respective fields.

Now a day, the term 'Scientometrics' is used for the application of quantitative methods to the history of sciences and obviously overlaps with bibliometrics to a considerable extent.

6. COMPONENTS OF BIBLIOMETRICS

The present-day bibliometric research is aimed at the following three main target-groups that clearly determine topics and sub-areas of "contemporary bibliometrics".

(i) Bibliometrics for bibliometricians (Methodology)

This is the domain of basic bibliometric research and is traditionally funded by the usual grants. Methodological research is conducted mainly in this domain.

(ii) Bibliometrics for scientific disciplines (Scientific information)

The researchers in scientific disciplines form the bigger, but also the most diverse interest group in bibliometrics. Due to their primary scientific orientation, their interests are strongly related to their specialty. This domain may be considered an extension of science information by metric means. Here we also find joint borderland with quantitative research in information retrieval.

(iii) Bibliometrics for science policy and management (science policy)

At present this is the domain of research evaluation and the most important topic in the field. Here the national, regional, and institutional structures of science and their comparative presentation are in the foreground.

7. APPLICATIONS OF BIBLIOMETRICS

Bibliometrics as a technique has extensive applications in identifying the research trends in a subject, trends in a authorship and collaboration in research, core periodicals, obsolescence and dispersion of scientific literature useful in estimating the comprehensiveness of secondary periodicals, studying publications by scientists, citation studies and so on.

Further, bibliometrics could be used in the identification of emerging research areas. The popularly in the adoption of bibliometric techniques in various disciplines stimulated stupendous growth of literature on bibliometrics and its related areas. The techniques are now being vigorously pursued and with the result, it has been found that one fourth of all the articles published in a Library and Information Science periodicals also carry a large number of articles on bibliometrics. These techniques are being used for a variety of purpose like determination of various scientific indicators, evaluation of scientific output, selection of journals for libraries and even forecasting potential Nobel Laureates. In the recent years, there has been an explosive growth in human knowledge. In fact, the nature and tempo of growth has been such as too far outstrip the achievements of the past centuries.

As science itself grow in extension and intention, the number of scientists increases. So obviously does the volume of literature generate by the scientific community. In fact, the growth of literature has caused a fairly widespread alarm and the term that describes explosion is also known as information explosion. De solla price claimed, that the science literature has grown exponentially in the last three centuries with a doubling rate of approximately 15 years.

Some of the areas of bibliometric techniques are:

a. To quantify research and their growth
b. To identify comprehensiveness of secondary periodicals.
c. To identify uses and authors of secondary periodicals
d. To quantify the usefulness of adhoc and retrospective SDI services.
e. To identify the core journals in different disciplines to formulate a need-based acquisition policy.
f. To initiate effective multi-level network system.

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g. To regulate inflow of information and their communication.
h. To develop norms for standardization.
i. To predict productivity of Publishers, individuals author organization, country or that of an entire discipline.

8. SCIENTOMETRICS

Scientometrics is a branch of the science 'Science of Science'. Haitun treats 'Scientometrics', as scientific disciplines, which performs reproducible measurements of scientific activity and reveal its objective quantitative regularities.

According to him, Scientometric methods include statistical and thesaurus methods, and indicators as to the number of citations, term etc. There are two aspects within science of science, viz.,

1. The analytical aspect which deals with the general laws of the development of science as a knowledge system and a specific social institution; and
2. The normative aspect that deals with the development of practical recommendations for raising research efficiency.

Scientometrics are used to measure scientific activities, mainly by producing statistics on scientific publications indexed in databases. They are flexible tools used to study the sociological phenomena associated with scientific communities, to conduct scientific/strategic, technical, technological or competitive monitoring, to design and manage research programs and to evaluate research. They are extremely valuable methods for evaluating research output, positioning studies and conducting foresight studies in science and technology. Scientometric tools could be used to measure and compare the scientific activities at various levels of aggregation including institutions, sectors, provinces and countries. They could also be used to measure research collaborations, to map scientific networks and to monitor the evolution of scientific fields. Scientometric indicators give policymakers objective, reproducible and therefore verifiable information that goes beyond the anecdotal.

8. INFORMETRICS

The field informetrics took the place of the originally broader specialty bibliometrics. The term informetrics was adopted by VINITI (Gorkova, 1988) 12 and stands for a more general subfield of information science dealing with mathematical statistical analysis of communication processes in science.

In contrast to the original definition of bibliometrics, informetrics also deals with electronic media and thus includes topics such as the statistical analysis of the (scientific) text and hypertext systems, library circulations, and information measures in electronic libraries, models for Information Production Processes and quantitative aspects of information retrieval as well. Otto Nacke of West Germany first proposed the term 'Informetrics' according to Brookes, in 1979. The term's acceptance data since 1987 when, B.C. Brooke suggested during the international conference of bibliometrics and theoretical aspects of Information Retrieval in Diepenbeek, Belgium that the term informetrics included in the name of the following conference, scheduled for London, Canada in 1989. This meeting was thus named- International Conference on Bibliometrics, Scientometrics and Informatrics. The name of the third meeting in the series held in Bangalore, 1991 in India, signals the final acceptance of this term.

"Informetrics is the study of the quantitative aspects of information in any form, not just records (or) bibliographies and in any special group not just scientists. Thus it looks at the quantitative aspects of informal (or) spoken Communication as well as recorded and of information needs and uses of the disadvantaged not just the intellectual elite.''

Informetrics deals with the measurement, hence also the mathematical theory and modeling of all aspects of information and the storage and retrieval of information. It is mathematical meta information, i.e. a theory of information, scientifically developed with the aid of mathematical tools. It is clear from the definition of these terms that they are all synonymous and even used interchangeably.

9. CITATIONS ANALYSIS

Martyn has defined citation analysis as "the analysis of citations or references or both which form part of the scholarly apparatus of primary communications. The techniques used for putting items of references in some kind of rank or order, whether they are journals or author cited".

A citation is a reference to a document given by a more recently published document. The document citing is the citing document, and the document that receives the citation is the cited document. Citation analysis involves counting the number of citations to a particular document for a period of time after its publication (this is sometimes called direct citations).

The traditional understanding of the citation function is that the frequency with which a document is cited can be taken as a measure of the impact or influence of that document on the citing literature. Citation analysis leads to more sophisticated methods, such as co-citation analysis, mapping of the literature, bibliographic coupling, and coword

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analysis. These methods, individually and in combination, strides to find information patterns, by analyzing reference and citation patterns as well as word use frequencies, combined with statistical analysis.

According to Aina, citation analysis is a research method in which references cited are statistically analyzed to find what journals are cited by researchers in a particular discipline. When one author cites another author, a relationship is established. Citation analysis uses citations in scholarly works to establish links. Many different links can be ascertained, such as links between authors, between scholarly works, between journals, between fields, or even between countries. Citations both from and to a certain document may be studied. One very common use of citation analysis is to determine the impact of a single author on a given field by counting the number of times the author has been cited by others. (Osareh 1996).

Citations are used in scholarly works to give credit to or acknowledge the influence of previous works, or to refer to authorities. Citations permit readers to put claims to the test by consulting earlier works. Authors often engage earlier work directly, explaining why they agree with, or differ from, earlier views. Ideally, sources are primary (first-hand) and recent.

10.CONCLUSION:

Bibliometrics has emerged as the most active field of library and information science. It is estimated that literature on this topic occupies more the 25% percent of the total contribution in library and information science. Citation analysis studies form a major portion of it. The rate of growth of the literature is obvious from the number of entries of the bibliohraphics on the subject. A major portion of these studies pertains to the application of bibliometric. However, there is a long way to go in achieving perfection in the studies. Even the widespread use of computers for retrieval, counting and analysis are unlikely to achieve perfection in the studies. The changes those re frequently occurring in the publication practices are likely to complicate the studies in future. In such circumstances, it is advisable to consider the results of such studies are more guidelines rather than ends in themselves.

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