Informetrics: an emerging subdiscipline in information science

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Introduction

The aim of this article is to present for Asian library and information science (LIS) professionals the many new possibilities which "informetrics" offers for those who want to explore databases not only as a registry but also as an analytical tool. It involves exploring online databases not only to access documents or find facts, but also to trace trends and developments in society, scientific disciplines, production and consumption areas. This type of information in the databases is visible only for the intelligent searcher and for those who have learned how "to read between the lines" of electronic information. Modern information technology provides a whole range of possibilities to add new value to the results of online searches; it offers great potential for those who want to develop their own niches and service specialities.

Bibliometrics or informetrics

Bibliometrics is traditionally associated with the quantitative measurement of documentary materials. It refers to a variety of regularities taken from different fields and exhibiting a variety of forms. Although bibliometric distributions differ greatly in appearance, they can be conceptualised as versions of a single regularity, so that we can properly speak of bibliometric laws and their manifestations. Bradford's Law of scattering, Zipf's Law and Lotka's Law are the best known laws dealing with important phenomena or "regularities" found in science communication.

For the majority of LIS professionals this sounds very traditional – a "dusty" part of the information science field; and with few exceptions it is a neglected area in current LIS curricula. It is not yet properly understood that advanced online search facilities and information retrieval (IR) techniques have considerably increased the potential of bibliometric research methodology and are opening up new possibilities for tracking down analytical information in large collections of bibliographic data. Linking the theoretical and practical aspects of information retrieval with the methodological and experimental research programmes in bibliometrics offers new, integrative and interdisciplinary research approaches – in which LIS professionals should participate.

Originally the field was characterised by enthusiastic researchers and was mainly a side interest for scientists, who later integrated interdisciplinary

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approaches: mathematical and physical models on the one hand, and sociological and psychological methods on the other, as well as the long tradition of library science. In 1954, when Eugene Garfield proposed the creation of citation indexes, his primary aim was *to improve the retrieval of science information*, and to introduce an alternative way to review scientific articles, bypassing linguistic and indexing-based forms. At that time there was widespread dissatisfaction with the array of traditional discipline oriented indexing and abstracting services. They were all inordinately late; indexing was inconsistent and uncoordinated; and selection policies left major gaps in coverage.

However, reviewing the 40 years' history of the ISI citation databases, we can state that the key advantage of citation indexing – its capacity to bypass the use of normal linguistic forms such as titles, keywords or subject headings – has not yet been discovered by a large part of the LIS community. The symbolic role played by the citation in representing the content of papers is an important dimension of information retrieval: in combination with various natural language expressions, citation indexes can greatly improve comprehensive literature searches.

Thus citation indexes have been primarily used for another purpose than was their founder's vision. The idea of average citation frequencies (that is, journal impact factors), now so widely used for evaluation analysis, has become the most used derivative metric of citation analysis and has received much greater attention than the originally proposed use of citation indexes to retrieve information.

Since the early 1980s, bibliometrics has evolved into a distinct scientific discipline with several subfields and the corresponding scientific communication structures. (The international journal *Scientometrics*, the first periodical specialising in bibliometric topics, was published in 1979; international conferences started in 1983.)

The individual identities of the subfields "bibliometrics", "informetrics", "scientometrics" and "technometrics" are unfortunately not very clear, and there is chaos in the terminology. At the 1987 international conference some thoughts were given to changing the name of the discipline to "informetrics", and since the late 1980s there has been some support for use of this term. But alongside or parallel with this, both "bibliometrics" and "scientometrics" are frequently used terms. The field is becoming a scientific discipline including all the statistical and mathematical aspects connected with library, documentation and information problems with strong links to the theoretical aspects of information retrieval.

Traditionally bibliometrics is aimed at three target groups:

(1) *Bibliometricians.* This is the domain of basic bibliometric research where the research activities of most LIS professionals belong. Investigation of the field's own "toolkit" by studying its models and empirical laws, elaborating its IR processes and methodological implications are the

major research areas traditionally funded by research grants or financed by scientists themselves.

(2) *Scientific disciplines.* This is a bigger but also the most diverse interest group in the field. Owing to researchers' primary scientific orientations in their own disciplines, their interests are often strongly related to their speciality. Research and special librarians in cooperation with domain specialists are often involved in studies of research frontiers, trends, gaps and similarities in research efforts at institutional, national and international levels.

(3) *Science policy and business.* This is the smallest but financially the most potent group. Their studies are at the meso- and macro-levels where national, regional and institutional structures of science and their comparative presentation are in the foreground. Ties with the social sciences, sociology, economics and policy analysis are growing closer.

The field of bibliometrics as a whole includes all quantitative aspects and models of science communication, storage, dissemination and retrieval of scientific information. This definition of the scope of bibliometric research areas is intentionally wide in order to integrate all existing orientations such as applications to science policy, library science and information retrieval.

Although the field is rapidly growing, bibliometrics is in a crisis today. Negative developments include: subfields are drifting apart; there is a lack of consensus not only on terminology, but also on some fundamental questions and internal communication; because of the domination of science policy and business interests in commissioning and funding research, there is a shift from basic and methodological research to applied bibliometrics. The audience has changed considerably, and every laboratory or "school" forms its own students according to the institution's profile. This differentiation normally leads to an enrichment of the thematic structure of a science, but here, because of an absence of integrating personalities, it is leading to disorientation and a breakdown in communication. Furthermore, the rising costs of bibliographic data and vendor monopoly limit bibliographic research (Glänzel and Schoepflin, 1994).

The challenge for LIS professionals

In the current state of professional development there is a great challenge for LIS professionals all over the world to improve their analytical skills, and in combination with advanced online search skills, to add value to the services they offer.

Owing to the frequent use and misuse of citation analysis for the evaluation of individual research performance, LIS professionals generally show little interest in the implication of quantitative analysis for their services. There is considerable emotion when citation analysis is discussed in connection with research evaluation – a field which suffers from inadequate tools for objective assessment. This is why the subject of validation is so important. While there is

a huge literature on citation analysis, there are only a few studies that could be called "validating", that confirm its value in literature searching or evaluation research.

Evaluation studies

Therefore, LIS professionals should take an active part in these discussions and use their skills and ability to adjust these – sometimes very simplistic – evaluations, adding or correcting data when necessary. The following examples of problem areas and work tasks illustrate where LIS professionals might demonstrate and practise the "sensible use" of bibliometric methods for the benefit of their own local research community or to gain analytical data to support "informed" management decisions in their environment:

- Comparison of bibliometric indicators with expert opinions – a methodology which has proved successful in favour of bibliometric measures predicting expert judgements in assessing research performance.
- Correlations between citation impact and peer review to make evaluation studies more reliable: it is well known that the evaluation of a person by scientometric methods needs more caution than bibliometric analyses of countries, institutions or groups.
- Application of citation data in studies designed to test various hypotheses or conjectures, as well as for the identification of key people, papers, journals and institutions in various scientific and scholarly specialities.
- The ranked status of core scientific journals is evaluated today exclusively on the basis of ISI's CD-ROM product, the yearly Journal Citation Report, which is produced by the citation frequency calculation of articles published in the journals. The journal citation impact factor, however, can also be calculated in online mode, using the citation databases set up by DIALOG or other large international hosts. It has been shown that comprehensive online bibliometric analyses are in many ways easier, faster and less expensive to perform "locally" than those made using the CD-ROM versions.

These "local" online analyses can be designed to match the aim of the evaluation, to check if calculations are based on correct data, and to eliminate discrepancies of current quantitative citation studies. There are many ways to carry out citation studies and citation impact analysis to satisfy "useful purposes" in supporting the interests of the research environment (see, for example, Hjortgaard Christensen and Ingwersen, 1996; Ingwersen and Hjortgaard Christensen, 1997; Wormell, 1998).

Navigating the literature

- Citation indexes enable the searcher to locate subsequent – and especially current – descendants of particular papers or books. As a tool

for navigating the literature, citation indexes can expand the scope of the search by retrieving not only those papers that cited a key work, but also those related to the citing references.

- The symbolic role played by citation in representing the content of papers is an important dimension of information retrieval: in combination with various natural language expressions, citation indexes can greatly improve comprehensive literature searches. The key advantage of citation indexing – its capacity to bypass the use of normal linguistic forms such as titles, keywords or subject headings – is yet to be discovered by many online searchers.

Education and training of the research community

LIS professionals might see themselves as teachers or tutors in using citation indexes as a retrieval and dissemination device for the research community. Although the Science Citation Index (SCI) and Social Science Citation Index (SSCI) are frequently used in most major research libraries of the world, because of the conservative nature of education in science, medicine and the humanities, only a fraction of scientists, physicians or scholars ever receive formal instruction in the use of citation indexes. With rare exceptions researchers do not encounter the Art and Humanities Citation Index (AH&CI) even when they enter graduate school. Thus LIS professionals can assist them in discovering this dimension of information retrieval.

Without bolstering up the professional image and status of the LIS field (which sometimes happens in self-centred environments) one should draw attention to the usefulness and appreciation of LIS professionals' intermediary role in accessing and refining information, to satisfy their clients' needs.

The sophisticated value of online information provision today is not to use databases only to retrieve data and information, but also to analyse/synthesise the findings and combine them with other information (data mining). Thus online searching should be understood as a value-adding process in terms of the selection and refinement procedures based on skilful search tactics and intelligent strategies. To provide this type of information service, the searcher needs to have analytical skills, the ability to think creatively and be familiar with advanced online search techniques. Modern LIS professionals, using bibliometric methods to explore databases and in their analytical work, have great potential to develop new service niches and specialities. This can rapidly move them toward the upper echelons of information work hierarchies in their environments.

Centre for informetric studies

The newly established Centre for Informetric Studies (CIS) at the Royal School of Library and Information Science in Copenhagen is based on the long established tradition of the school in conducting bibliometric studies, and on more recent research results generated in subject areas such as information

retrieval theories and methodologies, research evaluation, trend analysis, issue management, and business and social intelligence. CIS functions as an interdisciplinary unit of the school to carry out cooperative research in various fields.

"Informetric studies" signifies the new approach of CIS to the scientific study of information flows: improved bibliometric methods are applied not only to scientometric studies and research evaluations of science and technology (S&T) but also to the analysis of their mutual, societal, industrial and other specific relations. CIS has also extended traditional bibliometric analyses to cover non-scholarly communities where information is produced, communicated and used.

Since the use of quantitative methodologies is an underexplored area of current LIS research, the centre has been working to reinforce the link between bibliometrics and information retrieval. Ingwersen and Hjortgaard Christensen have in recent years discussed the possibilities, and to some extent the limitations, of performing publication and citation analyses online. By means of illustrative case studies and examples in their publications they provide a detailed description of the advantages and shortcomings of the various methods, as well as possible solutions for specific problems (Hjortgaard Christensen and Ingwersen, 1996; Ingwersen and Hjortgaard Christensen, 1997).

Another related research area is the analysis of current indexing and retrieval procedures as a means of enhancing the representation of knowledge embedded in bibliographic texts and improving intellectual access to stored information (Ingwersen and Wormell, 1986; 1989; Wormell, 1994).

In the last ten years centre researchers have been involved in Danish case studies combining bibliometric methodologies and the use of large-scale databases in analytical works, for trend analysis and knowledge mapping. In cooperation with market researchers and other domain experts they gathered analytical data and information which served as input for important management decisions and policy formulation (Ingwersen and Wormell, 1990). These investigations exemplified the benefits of interdisciplinary research, where bibliometrics, IR and management methodologies interacted in a fruitful way.

These experiences provided the philosophical foundation of CIS:

- to make bibliometric methodologies into a workable and "useful" tool in the hands of modern LIS professionals;
- to move bibliometrics from the traditional area of scholarly communication of information;
- to combine it with the use of advanced IR techniques;
- to promote the use and exploration of databases and networks as analytical tools for "informed" decision making and policy formulation.

The inauguration of the Centre for Informetric Studies took place on 15 December 1997 with Dr Eugene Garfield, Chairman Emeritus of ISI, as invited speaker. In his presentation, "From citation indexes to informetrics: is the tail now wagging the dog?", Dr Garfield gave a synoptic review of citation indexes for information retrieval, information dissemination and writing the history of contemporary science. He emphasised that the establishment of the Centre means a transformation of citation analyses into the new field of informetrics. This event signifies the emergence of integrative approaches within the subfields of bibliometrics, as well as the revival of interest in quantitative studies in LIS education and training programmes.

It is hoped that the methodologies and case studies developed by CIS researchers will enhance the use of online databases in developing areas of the Asian region. Using the classical methodologies of bibliometric analysis together with modern online search facilities, LIS professionals can considerably extend the horizons of their work: they can access not only entire documents or parts of documents, but also trace trends and developments in the region. By quantitative analysis they can map new paths in specific research, production and consumption, or locate unique pieces of high-value information from the large quantity of electronic information.

The samples below exemplify current CIS research activities. (For more detailed information on projects, publications, courses and seminars, informetric resources, etc., see the CIS home page: http://www.db.dk/cis.)

Sample CIS research studies

Informetric analyses on the World Wide Web

CIS researchers have studied the interesting idea of utilising informetric methods on the World Wide Web (WWW) and started to lay the basis of an emerging area of "webmetrics". Recent publications have presented a workable method for general informetric analysis on the WWW, accompanied by case studies analysing Danish, Norwegian, Swedish and international Web sites, and their relative visibility on the Net compared with relevant positions in the scientific databases (Almind and Ingwersen, 1997; Ingwersen, 1998).

Others are investigating the WWW from quantitative viewpoints, but the CIS studies are elaborating on the idea of carrying out the same types of informetric analyses on the WWW as is possible via a citation database. It is obvious that informetric methods using word counts can be applied; what is new is to regard the WWW as a citation network where traditional information entities, and citations from them, are replaced by Web pages. These pages are the information entities on the Web, with hyperlinks from them acting as citations.

Discussions on the most important data elements of webmetrics can be summarised as follows. In the ISI's citation databases descriptors are found in three forms: author keyword, keywords plus and research fronts. On the Web descriptors are given either by author or by frequencies. For the subject access points of Web pages an author can use tags, such as and .

Frequencies of terms are measured by some Web indexes. The titles of the Web pages are found either within the <TITLE> and/or <H1> tag, and can uniquely be identified by the URL of the page. Whether the author is a person or corporate source can only be identified manually. Corporate source or affiliation for Web pages is given by the first part of the URL, but the institution hosting a Web page is not necessarily connected with the author of the Web page. Problems and disadvantages in using informetric analyses on the WWW are the same as those relating to citation indexes (restrictive file structures together with flaws in data validity). The lack of any enforced conformity of form and content in Web pages, together with the dynamic and real time nature of the Web, creates both advantages and disadvantages in analytical work, and it is an exciting process to test how traditional search methodologies function on this new platform.

Almind and Ingwersen in 1996-97 tested and described the core of these options, and implemented them to draw a picture of Denmark's use of the WWW compared to Norway and Sweden, together with an overview of the types of Web page, discipline, size and number of links. Webmetrics can be used for many purposes; and in the context of the Information Society 2000 programme in the Asian region there are enormous possibilities in using the WWW and HTML as analytical tools for tasks such as issue management, gathering of business intelligence and research evaluation.

Frontends in agricultural and food research, and the identification of export markets for the Danish food industry

In order to know in which areas agricultural research and knowledge production in Denmark should be intensified to improve the strategic position of Danish export production in the world market, the Danish Agricultural Research Council initiated a comprehensive study in 1989 to analyse developments and trends globally. Besides traditional market research tools there was a need to map certain international research activities where large-scale bibliographic databases were used.

Some "quick overviews" of the domain in other countries gave a general orientation about leading research globally. After discussions with domain experts and research managers the framework of the bibliometric study was outlined. By several cross-checks and analyses of results from six selected countries, the bibliometric study provided state-of-the-art information about international food research and the position of Denmark. Research managers used the results in their strategic work in developing competitive export products *(Bibliometrisk analyse af udviklingstendenser i fødevareforskning og produktion*, 1989).

A follow-up study of similar scope was carried out in 1996 to test the validity of the results from the previous study and to improve the methodology using new online search facilities (RANK command) in the combination of Excel. The period of analysis was 1984-95. The results were used to see if the trends from 1989 had continued; to assess the "visibility" of Danish food research globally;

to ascertain which subjects or research domains had been emphasised in Denmark during the previous 12 years; to identify "strong" and "weak" areas in current Danish food research, as well as areas where Denmark has a chance of achieving results to promote exports. The cyclical movement of research intensity observed in certain areas was one of the most interesting findings of this study; further in-depth work in specific areas of food research, in close cooperation with the specialists in those areas, would appear to be worthwhile. (For the study results see Wormell, 1997.)

Assessing the international impact of scientific journals

The aim of this investigation is to present some quantitative methods for analysing scientific journals so that publishers and journal managers could see the current status of the journal as well as historical developments over a given period. The intention is to promote a deeper understanding of the impact of scholarly publications and to add a new dimension to the evaluation and ranking of scientific journals, balancing the simplistic use of ISI's journal impact factor.

The focus is on the international nature of scientific journals, measured according to the geographical distribution of authors, citations and subscribers. The following questions help to establish how international they are in scope and impact:

- Is the journal a national, international, continental, intercontinental product?
- What is the origin of the intellectual input (authors writing in the journal)?
- In which regions are the users concentrated (geographical distribution of citations)?
- Where does knowledge published in the journal go (from which subject areas are citations coming)?
- Does the distribution of users correspond with the distribution of subscribers?

The geographical distribution of authors-citations-subscriptions is measured and shown in diagrams. By inference analysis the hypothesis is tested whether there is a relation between distribution patterns of users and subscriptions. The correlation between these facts can have many explanations, but certainly it can stimulate useful ideas among publishers about unexplored market potential.

The "export of scientific knowledge" has also been highlighted – another indicator of impact – measuring the interdisciplinary character of the journal and the related field. This is to see whether the journal has the scientific strength and impact to penetrate traditional borders and limits of scientific communication within the given (home) field, and if it can attract authors and users from neighbouring disciplines or from a wider disciplinary area. Use of

the RANK command to list subject categories for the set of citations is an easy but very effective method for mapping the knowledge exported by the journal.

The sample of selected journals includes core LIS journals with the reputation of having an international readership, and one from related disciplines, for example computer science. The list has been defined as follows:

(1) Libri – *International Journal of Libraries and Information Services*.

(2) Scientometrics – *An International Journal for all Quantitative Aspects of the Science of Science, Communication in Science and Science Policy*.

(3) JASIS – *Journal of the American Society for Information Science*.

(4) J Doc – *Journal of Documentation*.

(5) IPM – *Information Management and Processing*.

(6) C&RL – *College and Research Libraries*.

(7) Comp J – *The International Journal of Computing*.

To describe the current status of the journals, as well as historical developments over the previous ten years, the analyses are divided into two publication periods, 1987-88 and 1992-93, each with a citation window of five years, 1987-91 and 1992-96.

The research findings clearly indicate that informetric analysis can provide useful, novel information and knowledge to support publication management decisions and editorial policy formulation. (CIS Report 7 presents diagrams for the seven selected journals with indicators; see Wormell, 1998.) The results are naturally of most interest to the publishers, editors and managers of the selected journals, but the methodology is applicable to all kinds of journals and subject areas. It is hoped that LIS professionals will discover its use for analysing their own journal collections, for advising researchers on the selection of journals for publishing their findings, and for allocating costly subscriptions.

Research intensity at regional and national levels

Table I shows bibliometrics research output at the national level. The figures are derived from the three major citation databases over the ten-year period, 1988-97. Entries are based on the geographical location of authors who published in the field in the core international scientific journals included in ISI's citation indexes. National publications and other more specific journals are not included in the analysis. Use of the RANK command in the DIALOG databases provided a list of detailed information on the countries from which the 683 publications (total production for 1988-97) came.

Aggregate regional figures from this Table show research output in bibliometrics as follows: 51.6 per cent Europe; 38.9 per cent North America; 9.6 per cent Asia and the Pacific; 3.1 per cent South America; 2.6 per cent Africa; 1.5 per cent Australia. It is well-known that there is a strong tradition of bibliometric analysis in India, and at several research and LIS institutions there

		(%)				(%)	
1	227	35.0	USA	30	3	00.5	Austria
2	52	8.0	The Netherlands	31	3	00.5	Brazil
3	37	5.7	Hungary	32	3	00.5	Croatia
4	37	5.7	Spain	33	3	00.5	Federal Republic of Germany
5	36	5.6	England	34	3	00.5	China
6	27	4.2	France	35	3	00.5	Taiwan
7	27	4.2	Germany	36	3	00.5	Ukraine
8	25	3.9	Canada	37	3	00.5	Wales
9	22	3.4	Belgium	38	2	00.3	Iran
10	21	3.2	India	39	2	00.3	Singapore
11	13	2.0	Israel	40	2	00.3	Yugoslavia
12	12	1.9	USSR	41	1	00.2	Byelarus
13	11	1.7	SSSR	42	1	00.2	Cameroon
14	10	1.5	Australia	43	1	00.2	Cuba
15	9	1.4	Japan	44	1	00.2	Czech Republic
16	9	1.4	South Africa	45	1	00.2	Czechoslovakia
17	7	1.1	Chile	46	1	00.2	Ethiopia
18	7	1.1	Mexico	47	1	00.2	Greece
19	7	1.1	People's Republic of China	48	1	00.2	Hong Kong
20	7	1.1	Russia	49	1	00.2	Kuwait
21	6	00.9	Denmark	50	1	00.2	Malaysia
22	6	00.9	Italy	51	1	00.2	Morocco
23	6	00.9	Scotland	52	1	00.2	North Ireland
24	5	00.8	Bulgaria	53	1	00.2	Pakistan
25	5	00.8	Finland	54	1	00.2	Qatar
26	5	00.8	Norway	55	1	00.2	Saudi Arabia
27	4	00.6	German Democratic Republic	56	1	00.2	Turkey
28	4	00.6	Nigeria	57	1	00.2	Venezuela
29	4	00.6	Sweden				—-end of results—-

Table I.
Geographical distribution of bibliometrics publications, 1988-97

are groups of scientists who are active in scientometric studies. Thus India is positioned in tenth place on the league table. Other Asian countries, however, are placed 34th and below, which certainly indicates that this subject area is underexplored in Asia.

Informetrics has to be introduced to LIS professionals to alert them to its use in modern information and library services. The Web site of the Centre for Informetric Studies offers information on readings, international courses, seminars and conferences, institutions and professional organisations promoting this field, significant events and personalities. It provides a first step: http://www.db.dk/cis.

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